



# UNIVERSITÀ DEGLI STUDI DI PALERMO

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| <b>DEPARTMENT</b>              | Scienze e Tecnologie Biologiche, Chimiche e Farmaceutiche                                                                                                                                                                                                                                                                                                |                      |                  |
| <b>ACADEMIC YEAR</b>           | 2019/2020                                                                                                                                                                                                                                                                                                                                                |                      |                  |
| <b>BACHELOR'S DEGREE (BSC)</b> | CHEMISTRY                                                                                                                                                                                                                                                                                                                                                |                      |                  |
| <b>INTEGRATED COURSE</b>       | ORGANIC CHEMISTRY II WITH LABORATORY                                                                                                                                                                                                                                                                                                                     |                      |                  |
| <b>CODE</b>                    | 13743                                                                                                                                                                                                                                                                                                                                                    |                      |                  |
| <b>MODULES</b>                 | Yes                                                                                                                                                                                                                                                                                                                                                      |                      |                  |
| <b>NUMBER OF MODULES</b>       | 2                                                                                                                                                                                                                                                                                                                                                        |                      |                  |
| <b>SCIENTIFIC SECTOR(S)</b>    | CHIM/06                                                                                                                                                                                                                                                                                                                                                  |                      |                  |
| <b>HEAD PROFESSOR(S)</b>       | GRUTTADAURIA<br>MICHELANGELO                                                                                                                                                                                                                                                                                                                             | Professore Ordinario | Univ. di PALERMO |
| <b>OTHER PROFESSOR(S)</b>      | GRUTTADAURIA<br>MICHELANGELO                                                                                                                                                                                                                                                                                                                             | Professore Ordinario | Univ. di PALERMO |
|                                | MARULLO SALVATORE                                                                                                                                                                                                                                                                                                                                        | Professore Associato | Univ. di PALERMO |
| <b>CREDITS</b>                 | 14                                                                                                                                                                                                                                                                                                                                                       |                      |                  |
| <b>PROPAEDEUTICAL SUBJECTS</b> | 01943 - ORGANIC CHEMISTRY I<br>00133 - GENERAL AND INORGANIC CHEMISTRY<br>15248 - CHEMICAL PREPARATIONS WITH LABORATORY PRACTICE                                                                                                                                                                                                                         |                      |                  |
| <b>MUTUALIZATION</b>           |                                                                                                                                                                                                                                                                                                                                                          |                      |                  |
| <b>YEAR</b>                    | 2                                                                                                                                                                                                                                                                                                                                                        |                      |                  |
| <b>TERM (SEMESTER)</b>         | 2° semester                                                                                                                                                                                                                                                                                                                                              |                      |                  |
| <b>ATTENDANCE</b>              | Mandatory                                                                                                                                                                                                                                                                                                                                                |                      |                  |
| <b>EVALUATION</b>              | Out of 30                                                                                                                                                                                                                                                                                                                                                |                      |                  |
| <b>TEACHER OFFICE HOURS</b>    | <b>GRUTTADAURIA<br/>MICHELANGELO</b><br>Monday 12:00 13:00 Studio, Viale delle Scienze, Ed. 17<br>Wednesday 12:00 13:00 Studio, Viale delle Scienze, Ed. 17<br><br><b>MARULLO SALVATORE</b><br>Tuesday 11:00 13:00 Dipartimento STEBICEF-Viale delle Scienze, Edificio 17<br>Thursday 11:00 13:00 Dipartimento STEBICEF-Viale delle Scienze, Edificio 17 |                      |                  |

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| <b>PREREQUISITES</b>      | Concepts taught in the course of Organic Chemistry I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>LEARNING OUTCOMES</b>  | <p>Knowledge of the tools for the recognition of different functional groups, of the various classes of reactions and different classes of compounds, as well as of the possible transformations associated with them.</p> <p>Knowledge of basic safety rules and conduct in an organic chemistry laboratory.</p> <p>Knowledge of glassware and basic instrumentation of an organic chemistry laboratory.</p> <p>Knowledge of the main methods of separation and purification of organic molecules. Acquisition of manual dexterity required for the development of a simple reaction.</p> <p>knowledge of the tools for the recognition of different functional groups, of the various classes of reactions and different classes of compounds, as well as of the possible transformations associated with them.</p> <p>Knowledge of the basic safety standards and conduct in an organic chemistry laboratory.</p> <p>Knowledge of glassware and basic instrumentation of an organic chemistry laboratory.</p> <p>Knowledge of the main methods of separation and purification of organic molecules.</p> <p>Comprehension of the reactivity of the different functional groups and of the various classes of compounds,</p> <p>Comprehension of separation technique and purification of an organic compound. Being able to realize a simple reaction.</p> <p>Ability to rationalize and predict the possible ways that can be used in organic synthesis. Ability to verify the goodness of an isolation and purification technique. Ability to assess the quality of the reaction conditions and improve them by taking simple precautions.</p> <p>Ability to use the specific language of Organic Chemistry. Learning skills Ability to understand the reaction mechanisms and structural factors that govern the reactivity of different classes of compounds, and their application in organic synthesis and in the study of biochemical processes.</p> <p>Ability to the development of a simple reaction.</p> <p>Ability to realize a synthetic approach and a retrosynthetic analysis.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>ASSESSMENT METHODS</b> | <p>For the first module: Oral exam. On request of the student, an ongoing evaluation during the period of suspension of classes will be provided. In this case, the topics covered will be clearly indicated by the teacher. Those who pass the test in progress will support the final exam on the topics covered in the second part of the program.</p> <p>For the laboratory module: observation and monitoring during the experiences and multiple choice tests.</p> <p>The final grade will take into account the theory module and laboratory module.</p> <p>The questions will focus on the formation of C-C bonds, organometallic catalysis, heterocyclic, biological molecules (lipids, amino acids, sugars, proteins, nucleic acids)</p> <p>It will be proposed retrosynthetic analyses and synthetic approaches to target molecules</p> <p>Final assessment aims to evaluate whether the student has knowledge and understanding of the topics, he has acquired jurisdiction to interpret and independent judgment of concrete cases. The threshold of sufficiency will be reached when the student shows knowledge and understanding of the subjects at least in broad outline, and has minimal application skills (simple synthesis and Retrosynthetic analysis) regarding the resolution of specific cases; It will also have presentation skills and argumentative as to allow the transmission of his knowledge to the examiner. Below this threshold, the examination will be insufficient. The more, however, the examinee with its argumentative and presentation skills can interact with the examiner, and the more his knowledge and application capabilities go into detail on the subject of discipline occurs, the more the assessment is positive. The assessment is carried out of thirty.</p> <p>The final evaluation predicts different classes as described in the following:</p> <ol style="list-style-type: none"> <li>1) Basic knowledge of course topics and limited capacity of knowledge processing and of correlation among the various topics. Sufficient capacity analysis of the proposed phenomena. Reduced ability of judgement and of exposure of the pursued procedures (rating 18-21)</li> <li>2) Good knowledge of course topics and good capacity of knowledge processing and of correlation among the various topics. Good capacity of analysis of the proposed phenomena. Good ability of judgement and of exposure of the pursued procedures (rating 22-24)</li> <li>3) Very good knowledge of course topics and rather good ability of knowledge processing and of correlation among the various topics. Really good capacity of analysis of the proposed phenomena. Really good ability of judgement and of</li> </ol> |

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|                         | <p>exposure of the pursued procedures (rating 25-27)</p> <p>4) Excellent knowledge of the topics, excellent and prompt capacity of knowledge processing and of correlation among the various topics by applying the acquired knowledge even to contests different from those proper of the course. Very good capacity of analysis of the proposed phenomena. Very good judgement and exposure ability of the pursued procedure (rating 28-30 )</p> <p>5) Excellent knowledge of the topics, excellent and very smart capacity of processing knowledge and of correlation among the various topics by applying the acquired knowledge even to contests different from those proper of the course. Excellent capacity of analysis of the proposed phenomena. Excellent judgement ability and of exposure of the pursued procedure (rating 30 cum laude).</p> |
| <b>TEACHING METHODS</b> | Frontal lessons, laboratory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

## MODULE ORGANIC CHEMISTRY II

*Prof. MICHELANGELO GRUTTADAURIA*

### SUGGESTED BIBLIOGRAPHY

W. H. Brown, B. L. Iverson, E. V. Anslyn, C.S. Foote "Chimica Organica", V Ed., 2015, EdiSES (Napoli)  
G. A. Pagani, A. Abbotto, "Chimica Eterociclica", Piccin (Padova) 1995

Testi di consultazione per tematiche specifiche

S. Warren, "Organic Synthesis. The Disconnection Approach", J.Wiley, 1996.

Monografie specifiche dalla letteratura e appunti forniti dal docente disponibili sul portale studenti

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|-------------------------------|---------------------------------------------------|
| <b>AMBIT</b>                  | 50136-Discipline chimiche organiche e biochimiche |
| <b>INDIVIDUAL STUDY (Hrs)</b> | 136                                               |
| <b>COURSE ACTIVITY (Hrs)</b>  | 64                                                |

### EDUCATIONAL OBJECTIVES OF THE MODULE

The course of Organic Chemistry II is aimed at the completion of Basic Organic Chemistry for degree in Chemistry. The predominant educational objective resides in the enhancement of organic synthesis. For this purpose new classes of reactions (pericyclic reactions, reactions catalyzed by metals, reverse polarity) and retrosynthetic approaches will be presented. In addition, the introductory elements to the study of heterocyclic compounds and the structural aspects and reactivity of molecules of biological interest will be presented.

## SYLLABUS

| Hrs | Frontal teaching                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| 4   | Review reactions to the carbonyl: Nucleophilic addition - nucleophilic substitution acyl. Review of electrophilic substitution reactions / nucleophilic aromatic<br>Oxidation and reduction reactions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 10  | C-C bond formation reactions: Aldol Reaction - Claisen Condensation and Dieckman reaction - Enamines - Synthesis with the acetoacetic ester - Synthesis with the malonic acid ester - Conjugate addition to alpha, beta-unsaturated carbonyl compounds, Michael reaction, Robinson annulation - reagents lithium diorganocuprate - cross-reactions of enolates using LDA - kinetic and thermodynamic control in the formation of enolates. Synthetic applications and retrosintetiche analysis                                                                                                                                                                                                                                                                                                                                       |
| 1   | Short overview of protection and deprotection of functional groups                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4   | Formation of C-C bonds: Knoevenagel and Baylis-Hillman reactions. Wittig and modified Horner-Emmons-Wadsworth reactions- Dithianes, reverse polarity (Umpolung). synthetic applications and retrosintetiche analysis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 8   | Formation of C-C bonds: Organometallic catalysis: preparation, reactivity, applications in the synthesis. Heck reaction, Suzuki reaction, Sonogashira reaction, catalytic allylic alkylation, reaction of metathesis of alkenes. synthetic applications and retrosintetiche analysis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2   | Formation of C-C bonds. Pericyclic reactions: Diels-Alder reaction - Claisen Transposition - Cope Transposition                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 4   | Heterocyclic compounds - aromaticity - tautomerism in heterocyclic structures: ring tautomerism (imidazoles, pyrazoles) and functional groups (hydroxy-azine / azoles and amino-azine / azoles).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 18  | Electron-rich heterocycles - Electrophilic Aromatic Substitution - Chloromethylation reaction - Mannich reaction - Formylation reaction (Vilsmeier) - Reactions with bases (lithiation) - Addition reaction to furan - Synthesis of pyrrole, furan and thiophene - benzofuran, indole and benzothiophene - indole synthesis. Electron-poor heterocycles - basicity - Electrophilic Aromatic Substitution - pyridine-N-oxide - nucleophilic aromatic substitution - Pyridons - Alkylpyridine - Synthesis of pyridine - Synthesis of Quinoline and isoquinoline. Pentatomic heterocycles with two heteroatoms: structural aspects and general approach to the synthesis (oxazole, imidazole, thiazole, isoaxazole, pyrazole). Imidazolium salts and thiazolium - Benzoin reaction. Synthetic applications and retrosintetiche analysis |
| 4   | Synthesis of heterocycles through pericyclic reactions: general aspects. 1,3-dipolar cycloaddition; cycloaddition of azadienes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1   | Lipids: Fatty acids - triglycerides - Soaps - Phospholipids - Steroids.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 3   | Carbohydrates: Monosaccharides - The cyclic structure of monosaccharides - Reactions of monosaccharides - Disaccharides (maltose, cellobiose, lactose, sucrose) - polysaccharides (amylose, amylopectin, cellulose) - glycosaminoglycans (hyaluronic acid, heparin)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 4   | Amino Acids and Proteins: - acid-base properties of amino acids - polypeptides and proteins - Primary Structure - Summary of polypeptides - Analysis of protein (Edman reaction, cyanogen bromide, enzymatic degradation). Synthesis of amino acids - Three-dimensional structure of polypeptides and proteins.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1   | Nucleic acids: - nucleosides and nucleotides - The structure of DNA - ribonucleic acids                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

**MODULE**  
**ORGANIC CHEMISTRY II - LABORATORY**

*Prof. SALVATORE MARULLO*

**SUGGESTED BIBLIOGRAPHY**

Marco D'Ischia - La Chimica Organica in Laboratorio - PICCIN - edizione 2003 - ISBN 978-88-299-1621-4  
Dispense del Docente

|              |                                                   |
|--------------|---------------------------------------------------|
| <b>AMBIT</b> | 50136-Discipline chimiche organiche e biochimiche |
|--------------|---------------------------------------------------|

|                               |    |
|-------------------------------|----|
| <b>INDIVIDUAL STUDY (Hrs)</b> | 60 |
|-------------------------------|----|

|                              |    |
|------------------------------|----|
| <b>COURSE ACTIVITY (Hrs)</b> | 90 |
|------------------------------|----|

**EDUCATIONAL OBJECTIVES OF THE MODULE**

The aims of the course are to provide the basics of organic chemistry laboratory. Acquisition of the safety standards and the most common laboratory procedures of purification and separation. To know the good procedures for develop a chemical reaction and for the treatment of the obtained mixture and the identification of the products.

**SYLLABUS**

| Hrs | Workshops                                                                                          |
|-----|----------------------------------------------------------------------------------------------------|
| 2   | Introduction to the course. Physical delivery. Safety standards. Instructions for the instruments. |
| 6   | Measurement of the melting points of the standard and organic substances unknowns                  |
| 6   | Separation of an acidic and a neutral substances by extraction                                     |
| 6   | benzoic acid purification via crystallization from water                                           |
| 6   | chromatographic techniques                                                                         |
| 6   | Reduction of 9-fluorenone                                                                          |
| 6   | Oxidation of 9-fluorenone with sodium hypochlorite                                                 |
| 6   | Halogenation of the trans-stilbene                                                                 |
| 6   | Dehydrohalogenation of 1,2 dibromo 1,2 diphenylethane                                              |
| 6   | Aldol condensation of benzaldehyde and acetone                                                     |
| 6   | Benzoin condensation catalyzed by thiamine                                                         |
| 6   | Oxidation of benzoin to benzyl                                                                     |
| 6   | Camphor reduction to borneol and isoborneol                                                        |
| 6   | GC-MS analysis of the reaction mixture                                                             |
| 6   | Synthesis of aspirin                                                                               |
| 4   | Recording and analysis of IR spectra. discussion of results                                        |