320064 - QOBA - Organic Chemistry and Applied Biochemistry

**Coordinating unit:** 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering

**Teaching unit:** 713 - EQ - Department of Chemical Engineering

**Academic year:** 2018

**Degree:** BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)

**ECTS credits:** 6

**Teaching languages:** Catalan, Spanish

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**Teaching staff**

**Coordinator:** Josep Garcia Raurich

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**Prior skills**

In order to successfully meet the objectives of this subject, students will be expected to have passed Chemistry (first semester).

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**Degree competences to which the subject contributes**

**Specific:**

1. CHE: Knowledge of material and energy balances, biotechnology, the transfer of materials, separation operations, chemical reaction engineering, the design of reactors, and the reuse and transformation of raw materials and energy resources.

**Transversal:**

2. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.

4. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
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Teaching methodology

In order for students to meet the objectives and acquire the competencies described above, this subject is organised in four different types of sessions:

- Face-to-face lecture and applied sessions.
- Distance independent-learning sessions.
- Distance teamwork sessions.

Face-to-face lecture and applied sessions:

In the lectures, the lecturer will introduce the theoretical fundamentals of the subject, concepts, methods and results, which will be illustrated with relevant examples to facilitate their understanding.

Most of the topics will be covered in the following types of classes:

- Lectures, with problem-solving examples.
- Lecturer-led problem-solving.
- Problem-solving in small groups (2-3 students) or individually. The lecturer will mark some of the problems assigned in class and return them to the students, so that they may track their progress over the course of the semester. These problems will count towards students' final marks.

Students' understanding of the content will be assessed over the course of two two-hour sessions.

Distance independent-learning sessions:

Students are expected to spend time outside of class studying the theoretical content in order to understand it and apply it correctly. Students should divide this time between the study of theoretical foundations and the application of these foundations to solve problems assigned by the lecturer. The lecturer will mark some of the assigned problems and return them to the students, so that they may track their progress over the course of the semester. These problems will count towards students' final marks.

Distance teamwork sessions:

Students are expected to spend time outside of class working in teams to solve one of the problems related to organic synthesis processes assigned by the lecturer. Using appropriate bibliographical sources, each student will have to search for instructions on how to correctly carry out the practical, draft a protocol for solving the problem, and orally present the protocol to the other students and the lecturer.

Each team will have tutoring/consulting time with the lecturer prior to the oral presentation of the solution to the problem.

The subject has been designed to ensure that students attain Level 2 of the independent learning, oral and written expression and teamwork competencies, although the last of these will not be assessed.

Students will be given educational materials covering the theoretical basis, the experimental procedure and the reading list for each of the practicals.

Students will receive communications and notifications by means of the UPC Digital Campus, which is currently available to lecturers and students.

Learning objectives of the subject
In this subject, students will learn to do the following:
- Apply general chemistry concepts related to organic chemistry acquired in the first semester.
- Recognise the various families of organic compounds by functional group.
- Associate the main organic reactions with functional group reactions.
- Understand the reaction mechanisms in which functional groups are involved.
- Understand and apply the stereoisomerism and conformational analysis of organic compounds.
- Understand of the procedures used in organic synthesis.
- Be familiar with the main natural products of interest to industry.
- Be familiar with the chemical and biochemical foundations of biotechnology.

Specific competencies
- Understand that organic chemistry is carbon chemistry.
- Be familiar with the large number of compounds that contain carbon.
- Understand that the chemical behaviour of these compounds is governed by functional groups.
- Understand that functional groups react by means of particular mechanisms, which makes it unnecessary to memorise an apparently disconnected set of reactions.
- Understand that the chemistry of natural products can be explained in terms of functional group reactions.
- Apply this knowledge to industrial processes.

### Study load

<table>
<thead>
<tr>
<th>Study load</th>
<th>150h</th>
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<tbody>
<tr>
<td>Total learning time:</td>
<td></td>
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<tr>
<td>Hours large group:</td>
<td>45h</td>
<td>30.00%</td>
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<tr>
<td>Hours medium group:</td>
<td>15h</td>
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<tr>
<td>Hours small group:</td>
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<tr>
<td>Guided activities:</td>
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<tr>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
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## Content

### TOPIC 1: INTRODUCTION TO INDUSTRIAL ORGANIC CHEMISTRY

<table>
<thead>
<tr>
<th>Learning time: 8h</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Practical classes: 1h</td>
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<tr>
<td>Self study: 5h</td>
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**Description:**
- Concept of isomerism: types
- Concept of functional group.
- Concept of reaction intermediate: types
- Concept of reaction mechanism: types.

**Specific objectives:**
On completing this topic, students will have acquired the ability to:
- Differentiate between empirical formula, molecular formula, structural formula and semi-structural formula.
- Correctly calculate empirical and molecular formulas.
- Differentiate between the various types of isomers.
- Apply the appropriate nomenclature rules to geometric and chiral stereoisomers.
- Differentiate between homolytic fission and heterolytic fission.
- Differentiate between different types of reaction intermediates.
- Differentiate between different reaction mechanisms.

### TOPIC 2: CHEMICAL BEHAVIOUR OF HYDROCARBONS

<table>
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<th>Learning time: 20h</th>
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<tbody>
<tr>
<td>Theory classes: 6h</td>
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<tr>
<td>Practical classes: 2h</td>
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<tr>
<td>Self study: 12h</td>
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**Description:**
- Free-radical reactions with alkanes, alkenes and alkynes.
- Carbocation reactions with alkenes and alkynes.
- Differences between 1,2 addition and 1,4 addition in conjugated dienes. Introduction to the concept of electron mobility.
- SAE reactions in aromatic compounds (benzene and derivatives).
- Conformational analysis of alkanes and cycloalkanes.

**Specific objectives:**
On completing this topic, students will be able to:
- Understand the differences between free-radical reactions and carbocation reactions.
- Understand the difference in complexity of the final products according to the reaction mechanism.
- Understand the concept of electron mobility as the foundation for resonance structures.
- Apply the concept of electron resonance to explain electrophilic aromatic substitution reactions.
- Perform conformational analysis of alkanes and, by extension, open-chain compounds.
- Understand the difference between staggered and eclipsed conformations, especially in cyclohexane and its derivatives.
### TOPIC 3: CHEMICAL BEHAVIOUR OF COMPOUNDS WITH AN OXIDATION STATE OF 1, 2 OR 3

**Description:**
- Reactions with alcohols and ethers. Influence of the type of alcohol (primary, secondary or tertiary) on the reaction mechanism.
- Differentiation between concerted and stepwise reactions.
- Differentiation between substitution and elimination reactions.
- Coexistence of both types of reactions.
- Carbonyl group reactions in compounds with oxidation state of 2 (aldehydes and ketones). Concept of nucleophilic addition.
- Carbonyl group reactions in compounds with oxidation state of 2 (acids and derivatives). Concept of acyl group substitution.
- Comparison of nucleophilic addition and acyl group substitution.
- Aldol condensation as a specific case of nucleophilic addition. Carbanion reactions.

**Specific objectives:**
On completing this topic, students will be able to:
- Differentiate between the chemical behaviour of primary, secondary and tertiary alcohols.
- Predict, on the basis of the nucleophile used, the type of reaction that an alcohol will undergo (nucleophilic substitution or elimination).
- Correlate the above two points.
- Differentiate between the behaviour of strong and weak nucleophiles in nucleophilic addition.
- Explain acyl group substitution and differentiate between it and carbonyl group nucleophilic addition.
- Understand the behaviour of carbanions.
- Explain aldol condensation.

**Learning time:** 32h  
- Theory classes: 8h  
- Practical classes: 3h  
- Self study: 21h

### TOPIC 4: ORGANIC SYNTHESIS

**Description:**
- Methods for obtaining the main aliphatic compounds.
- Interaction between various methods for obtaining organic compounds. Introduction to organic synthesis.

**Specific objectives:**
On completing this topic, students will be able to:
- Understand the main methods for obtaining organic products.
- Set up a multi-step organic synthesis.
- Optimise synthesis (i.e. use the smallest possible number of steps while obtaining maximum efficiency).

**Learning time:** 26h  
- Theory classes: 3h  
- Practical classes: 3h  
- Self study: 20h
## TOPIC 5. INDUSTRIAL ORGANIC PRODUCTS

**Learning time:** 20h  
Theory classes: 9h  
Practical classes: 3h  
Self study: 8h

### Description:

- Surfactants: structure and types.  
- Polymers: classification and types.  
- Free-radical, cationic and anionic polymerisation.

### Specific objectives:

On completing this topic, students will be able to:

- Differentiate between the various types of products developed to combat pests.  
- Understand the recent change in mindset in terms of respect for the environment.  
- Differentiate between soaps and synthetic detergents.  
- Understand the historical changes that have taken place in this field with the introduction of respect for the environment.  
- Understand the importance of azo dyes as an example of specific organic synthesis.  
- Understand the historical changes that have taken place in this field with the introduction of respect for the environment.  
- Understand polymerisation reactions as a complement to the reaction mechanisms covered in topics 2 and 3.  
- Understand the importance of these types of reactions in modern industrial organic chemistry.
**TOPIC 6: BIOMOLECULES**

**Learning time:** 22h  
Theory classes: 10h  
Practical classes: 2h  
Self study: 10h

**Description:**
- Characteristics of carbohydrates.  
- Disaccharides and polysaccharides.  
- Homopolysaccharide and heteropolysaccharides.  
- Characteristics of lipids.  
- Structure and properties of saponifiable lipids.  
- Structure and properties of non-saponifiable lipids.  
- Characteristics of amino acids. Acid-base properties.  
- Isoelectric point.  
- Peptide bond. Proteins.  
- Primary, secondary, tertiary and quaternary structure of proteins.  
- Denaturation of proteins.  
- Enzymes: definition, properties and classification.  
- Apoenzymes and holoenzymes.  
- Definition of cofactor, coenzyme, cosubstrate and prosthetic group.  
- Michaelis-Menten kinetics.  
- Lineweaver-Burk transformation.  
- Activation and inhibition of enzyme activity. Dependence on pH and temperature.  
- Denaturation of enzymes.  
- Nucleic acids: nucleosides and nucleotides.  
- DNA: Curriculum. Stabilising forces.  
- RNA: Curriculum.  
- Main types: mRNA, tRNA and rRNA. Characteristics and functions.

**Specific objectives:**
On completing this topic, students will be able to:
- Understand how carbohydrates are classified by Fischer projection.
- Correlate the cyclic structure of carbohydrates with that of cyclohexane.
- Recognise cyclic structure as a specific case of nucleophilic addition to the C=O double bond.
- Recognise the difference between oils and fats.
- Understand the importance of C=C double bonds in the fatty acid chain.
- Understand the wide range of substances classified as lipids and their relationship to more complex natural products.
- Understand how amino acids are classified by Fischer projection.
- Understand their amphoteric behaviour.
- Understand the structure and properties of oligo- and polypeptides.
- Understand the forces that stabilise protein structures.
- Understand that enzymes are special proteins that act as catalysts.
- Understand that enzymes are much more powerful than synthetic catalysts.
- Understand that enzymes are activated in aqueous solutions under very mild temperature and pH conditions.
- Understand that cells contain two varieties of nucleic acid: ribonucleic acid (RNA) and deoxyribonucleic acid (DNA).
- Understand that DNA forms part of genes, the hereditary material of cells, and contains instructions for producing the proteins that the organism needs.
- Understand that RNA is associated with the transmission of genetic information from the nucleus to the cytoplasm, where protein synthesis occurs.
- Understand that there are three types of RNA: messenger (mRNA), transfer (tRNA) and ribosomal (rRNA).

### TOPIC 7: CHEMICAL AND BIOCHEMICAL FOUNDATIONS OF BIOTECHNOLOGY

**Learning time:** 16h
- Theory classes: 7h
- Practical classes: 1h
- Self study: 8h

**Description:**
- Concept and brief historical overview of biotechnology.
- Characteristics of industrial biotechnological processes: obtaining the best biological catalyst for a specific process or function; obtaining the best environment for the function of this biological catalyst by means of a series of technical designs; processing material (separation and purification of the biological material produced).
- Industrial applications: ethanol production; acetone-butanol fermentation; production of antibiotics; animal cell culturing; production of biopolymers.

**Specific objectives:**
On completing this topic, students will be able to:
- Understand that biotechnology can be defined, broadly, as the application of biological organisms or systems to the production of goods or services.
- Understand that modern biotechnology is a highly interdisciplinary field with many areas of application.
- Identify the variety of raw materials that go into industrial biotechnological processes.
- Understand the use of microorganisms, cells and enzymes to obtain industrial products.
Qualification system

- First examination: 30%
- Second examination: 50%
- Assignments submitted: 20%

The unsatisfactory results of the first part examination can be redirected by submitting to a written global proof of the whole subject that will be carried out on the day set for the final exam and during the timetable stipulated for this exam. The qualification obtained in this exam will replace the initial qualification as long as it is superior.

For those students who meet the requirements and submit to the reevaluation examination (In order to qualify for the reevaluation of this subject, it is essential to be enrolled in the subject and have obtained a final grade between 3.5 and 4.9. In addition, it is necessary to obtain a minimum of 4 out of 10 of the overall grade of the practical exercises with the weighting established in this teaching guide.), the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

Bibliography

Basic:


Complementary: