



INTER-AMERICAN UNIVERSITY OF PUERTO RICO  
METROPOLITAN ENCLOSURE  
Faculty of Science and Technology  
Natural Sciences Department

Course for students of Biology, Biomedical Sciences, Natural Sciences, Microbiology,  
Chemistry and Medical Technology

## COURSE SYLLABUS

### I. GENERAL INFORMATION

Course Title:	Organic Chemistry II
Code and Number:	CHEM 2221
Credits:	4 Credits
Requirement:	CHEM-2221
Academic term:	Trimester: 2022-33
Contact hours:	Three hours and 50 minutes per week
Professor:	Luis A. Arias, Ph.D.
Office:	419
Office hours:	Monday: 12:05- 14:05 Wednesday: 12:05-14:05
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### II. Course description:

Theoretical and experimental study of organic compounds. Emphasis on spectroscopy, nomenclature, isomerism, synthesis, and reactions, including mechanisms of ethers, organometallic, carbonyl and carboxylic compounds, amines, and compounds of biological interest. Also included is the study of the Diels-Alder cycloaddition reaction according to the theory of frontier molecular orbitals. Requires 45 hours of lecture and 45 hours of closed face-to-face laboratory. Prerequisite: CHEM 2221

### III. TERMINAL AND TRAINING OBJETIVES

1. **General Aspects of the Structure - Determine the fundamental characteristics of the chemical bond of ethers, epoxides, carbonyl and nitrogen compounds, heterocyclic, carbohydrates, proteins and lipids.**

- 1.1 Recognize and substantiate the relative acidity of alpha hydrogens to the carbonyl group.
- 1.2 Determine the relative stabilities of the enolate ions.
- 1.3 Establish the correlation between acid strength and molecular structure of carboxylic acids: hybridization, inductive and resonance effects.
- 1.4 Establish the correlation between chemical reactivity and molecular structure of carboxylic acid derivatives.

2. **Nomenclature Aspects - Name the organic compounds mentioned according to the IUPAC systematic rules and through some trivial names.**

- 2.1 Write the chemical names of organometallic compounds.
- 2.2 Write the IUPAC name of ethers and epoxides including some of the most important trivial names.
- 2.3 Write the IUPAC name of aldehydes and ketones, including some of the most important trivial names.
- 2.4 Write the IUPAC name of carboxylic acids, including some of the most important trivial names.
- 2.5 Write the IUPAC name of acid halides, anhydrides, esters and nitriles.
- 2.6 Write the IUPAC name of the amines and their derivatives.
- 2.7 Classify carbohydrates and name them systematically.

**3. Reaction Mechanisms - Write the mechanisms and predict the structure of the products of reactions of addition, nucleophilic substitution, reduction and oxidation of carbonyl compounds.**

- 3.1 Write the equations and the mechanism for the opening reactions of epoxides with water, alcohols, reducing, and organometallic reagents.
- 3.2 Write the equations of the methods of obtaining ethers and epoxides.
- 3.3 Write the equations and the mechanism for the reaction of ethers with hydrogen halides.
- 3.4 Write the mechanisms and products of nucleophilic addition reactions to aldehydes and ketones: addition of H<sub>2</sub>O, alcohols, HCN, ammonia, amines and derivatives (hydrazine, phenylhydrazine), Grignard and Wittig reagents.
- 3.5 Grignard and Wittig reagents.
- 3.6 Discuss the general mechanism of the reactions of carboxylic acids and their derivatives: hydrolysis, alcoholysis, with ammonia, primary and secondary nitrogen, reaction with of carboxylic acids salts, addition of Grignard and organolithium reagents.
- 3.7 Write the mechanisms and products of the reactions of aldehydes and ketones with the following reducing agents: hydrogen, metal hydrides and hydrazine -KOH (Wolf- Kishner).
- 3.8 Write the mechanism and products of the reaction of carboxylic acids with alcohols and reducing agents.
- 3.9 Write the equations and mechanisms of amines reactions preparation from: alkyl halides, potassium phthalimide (Gabriel's method), nitro-type compounds, aldehydes, and amides.
- 3.10 Write the mechanisms and products of the reactions of amines with: alkyl halides, silver oxide (Hofmann elimination).

**4. Organic Synthesis - Propose synthetic methods to obtain organometallic reagents, alcohols, epoxides, carbonyl, nitrogen, and heterocyclic compounds, including moderate-level synthetic sequences.**

- 4.1 Write the equations of the methods of preparation of organometallic compounds.
- 4.2 Apply the use of Grignard reagents for the synthesis of alcohols.
- 4.3 Apply the use of organolithium compounds for the synthesis of alcohols.
- 4.4 Apply the use of organocuprates for the synthesis of alkanes.
- 4.5 Write the equations of organometallic compounds acting as Brønsted bases.
- 4.6 Write the equations of the methods of preparation of aldehydes and ketones.
- 4.7 Apply the use of protective groups for aldehydes and ketones in synthetic transformations of molecules with functional groups of different chemical reactivity.
- 4.8 Write the equations of the reactions of preparation of carboxylic acids from: their derivatives, alcohols, aldehydes, alkenes, alkylarenes and Grignard reagents.
- 4.9 Write the halogenation products alpha ( $\alpha$ ) to the carbonyl group of aldehydes and ketones.
- 4.10 Write the structures of the decarboxylation and formation products of  $\beta$ -keto acids or  $\beta$ -diesters.
- 4.11 Write the equations of the preparation methods for acid halides, anhydrides, esters, amides and nitriles.
- 4.12 Write the structures of the products of the reactions of carboxylic acid derivatives with emphasis on addition-elimination reactions.
- 4.13 Write the structures of the products of the reduction of carboxylic acid derivatives with LiAlH<sub>4</sub>.
- 4.14 Write the equations of the different methods of generating enolates, emphasizing the factors that determine their stability.
- 4.15 Write mechanisms and products of the following reactions: malonic ester synthesis, acetoacetic ester synthesis, aldol condensations inter and intramolecular condensation of esters (Claisen, mixed and intramolecular).
- 4.16 Apply the synthesis of the acetoacetic ester for preparing  $\alpha$ -mono-substituted, and  $\alpha,\alpha$ -di-substituted ketones.
- 4.17 Apply the synthesis of the malonic ester for preparing  $\alpha$ -mono-substituted and  $\alpha,\alpha$ -di-substituted carboxylic acids.

**5. Correlation of physical properties and molecular structure- Determine molecular structures of alcohols, ethers, epoxides, carbonyl compounds, nitrogen and heterocyclic compounds through**

**spectroscopic techniques: Infrared (IR), Nuclear magnetic resonance (proton,  $^1\text{H-NMR}$ ) and carbon-13 ( $^{13}\text{C-NMR}$ ), Mass Spectrometry (MS) and Ultraviolet/Visible (UV- Vis).**

- 5.1 Discuss the interaction between radiation energy and matter.
- 5.2 Describe the effect of infrared radiation on covalent bonds, absorption and different modes of molecular vibration.
- 5.3 Apply the existing correlation between infrared spectrum and molecular structure in the structural determination of organic compounds through correlation tables.
- 5.4 Discuss the phenomenon of nuclear magnetic resonance and the relationship between chemical displacement and molecular structure: inductive, anisotropic and hybridization effects.
- 5.5 Obtain and illustrate the use of the integration of signals in the proton spectrum,  $^1\text{H-NMR}$ .
- 5.6 Determine the structure of organic compounds based on the first-order  $^1\text{H-NMR}$  spectra and the corresponding  $^{13}\text{C-NMR}$  (single, coupled) spectra.
- 5.7 Determine the molecular structures of organic compounds by the complementary use of IR,  $^1\text{H-NMR}$  and  $^{13}\text{C-NMR}$  spectra.
- 5.8 Correlate the structure of a molecule with the DEPT spectra.
- 5.9 Discuss the interaction between the radiation energy of the UV-Vis region and matter.
- 5.10 Describe the electronic absorptions according to their different types of transition:  $\pi \rightarrow \pi^*$ ;  $n \rightarrow \pi^*$ ;  $n \rightarrow \sigma^*$ ;  $\sigma \rightarrow \sigma^*$ .
- 5.11 Identify the maximum absorption ( $\lambda_{\text{max}}$ ) of the most common chromophores and the factors that shift it: conjugation, substituents and solvent.
- 5.12 Calculate the molar absorption coefficient ( $\epsilon$ ) from the UV / Vis spectrum and the Lambert-Beer Law.
- 5.13 Use experimental data to determine the molar absorption coefficient ( $\epsilon$ ) from corresponding regression line.
- 5.14 Discuss the phenomenon of ionization of organic compounds.
- 5.15 Deduce the structures of the fragments of some simple molecules (alkanes, alcohols, halides, carbonyl compounds) from their mass spectrum.
- 5.16 Define and identify the following concepts in a mass spectrum: base peak, molecular ion, peak  $M + 2$ ,  $M + 4$ , etc.
- 5.17 Identify the presence of chlorine, bromine, and nitrogen in an organic compound from its mass spectrum and determine the molecular formula.
- 5.18 Determine molecular structures through the complementary use of mass spectra, IR, NMR and UV-Vis in combination with other experimental data.
- 5.19 Establish the correlation between molecular structure and spectroscopic characteristics for the structural determination of ethers.
- 5.20 Establish the correlation between molecular structure and spectroscopic characteristics for the structural determination of aldehydes and ketones.
- 5.21 Apply the correlation between molecular structure and spectroscopic characteristics for the structural determination of carboxylic acids.
- 5.22 Establish the correlation between molecular structure and spectroscopic characteristics for the structural determination of carboxylic acid derivatives.
- 5.23 Establish the correlation between molecular structure and spectroscopic characteristics for the structural determination of aromatic compounds.
- 5.24 Establish the correlation between acid strength and molecular structure of phenols using inductive and/or resonance effects.
- 5.25 Classify the different amines according to the degree of substitution and their constants of basicity  $K_b$ , taking into account the different characteristics that influence the  $K_b$  values: resonance, hybridization, inductive effect.
- 5.26 Correlate molecular structure and the spectroscopic data for structural determination of the amines.

**6. Correlation of Chemical Reactivity and Molecular Structure - Describe the chemical properties of alcohols, ethers, epoxides, carbonyl, nitrogen and heterocyclic compounds.**

- 6.1 Discuss the reactivity of the carbonyl group based on the polarity of the  $\text{C}=\text{O}$  bond, free electronic pairs, electronic and steric effects.
- 6.2 Write tautomeric equilibrium Ceto-Enol.

- 6.3 Determine the relative stabilities of enolate ions.
- 6.4 Establish the difference in reactivity between ethers and epoxides.
- 6.5 Establish the difference in reactivity between carboxylic acids and their derivatives in nucleophilic substitution reactions.
- 6.6 Establish the difference in reactivity between aldehydes and ketones with carboxylic acids and their derivatives in nucleophilic addition reactions.

**7. Frontier Molecular orbitals- Employ methods of graphic perturbation of molecular orbitals for the prediction of cycloaddition products.**

- 7.1 Classify dienes into conjugates and non-conjugates.
- 7.2 Apply the concept of  $\pi$  electron delocalization for a conjugated diene using, among others, the theory of resonance.
- 7.3 Represent the  $\pi$  type molecular orbitals of alkenes, dienes and conjugated polyenes based on their energies, the symmetry of the orbitals, the number of nodes and identify the frontier orbitals.
- 7.4 Recognize the minimum requirements to carry out a cycloaddition of  $4n + 2$  electrons  $\pi$ , as the Diels-Alder reaction.
- 7.5 Make retrosynthesis of the product of a cycloaddition to identify the diene and dienophile corresponding, according to the stereo selectivity of the reaction.
- 7.6 Apply the concept of LUMO and HOMO for the analysis of the molecular orbitals of Diels-Alder type reactions.

**8. Complex Polyfunctional Compounds - Determine the fundamental chemical characteristics, and biological function of mono-, di- and polysaccharides, amino acids and polypeptides or proteins.**

- 8.1 Recognize the structure of the most common lipids.
- 8.2 Describe the biological functions of some lipids or derivatives of these.
- 8.3 Determine the absolute configuration of monosaccharides in their Fischer projections.
- 8.4 Write the hemiacetal structures: furan and pyranose of the most common monosaccharides.
- 8.5 Write the conformational and Haworth formulas of anomeric sugars. Determine the relative stabilities of the D-glucose anomers: mutarotation, anomeric effect.
- 8.6 Write the formation equations of glycosidic acetals.
- 8.7 Discuss the structure, source and importance of some disaccharides such as maltose, lactose, sucrose and cellobiose.
- 8.8 Discuss the structure, origin and importance of some polysaccharides such as cellulose, starch, amylose, amylopectin and chitin.
- 8.9 Discuss the properties of amino acids:  $pK_a$ ,  $pK_b$ , amphoteric character, isoelectric point and electrophoresis.
- 8.10 Discuss the structural characteristics of amino acids with an emphasis on essential amino acids.
- 8.11 Write the mechanism of peptide bond formation and discuss its structural characteristics.
- 8.12 Write all possible structures in the formation of a tripeptide from three different amino acids
- 8.13 Discuss the different types of proteins and their function.
- 8.14 Explain the meaning and importance of the primary, secondary, tertiary and quaternary structures of a protein and the factors causing its denaturation.

**9. Molecular Modeling - Correlation of physical, chemical and molecular structure properties through computer molecular modeling.**

- 9.1. Apply molecular modeling to predict and describe the frontier molecular orbitals of alkenes and dienes in the Diels-Alders reactions.

**IV. COMPETENCES-** This course covers the following competencies for the BS Program in Chemistry

- Analyze chemical reactions based on their mechanisms and the factors that affect them.
- Know the procedures and regulations for the handling, use and disposal of chemical products

## V. COURSE CONTENT

TEXTBOOK: ORGANIC CHEMISTRY: JANICE GORZYNSKI SMITH **SIXTH EDITION**

Unit-Topics	Thematic Content	Chapter(sections)
1. Oxidations and Reductions	<ul style="list-style-type: none"> <li>▪ Oxidation reactions of:               <ul style="list-style-type: none"> <li>• alkenes to cis-1,2-diols, epoxides, allylic oxidation</li> <li>• alcohols to aldehydes, ketones or carboxylic acids</li> <li>• alkylbenzenes to <math>\alpha</math>-bromoalkylbenzenes and benzoic acid or derivatives</li> <li>• carbonyl compounds: aldehydes to carboxylic acids and methyl ketones to carboxylic acids</li> </ul> </li> <li>▪ Reduction reactions of alkynes to alkanes, <i>cis</i> alkenes and <i>trans</i> alkenes</li> </ul> Reduction of compounds with CZ bonds: <ul style="list-style-type: none"> <li>• alkyl halides to alkanes</li> <li>• epoxides to alcohols</li> <li>• hydroxyalkyl mercury acetate to alcohols</li> </ul> Reduction in the substituent of benzene derivatives <ul style="list-style-type: none"> <li>▪ Reduction of aldehydes and ketones to:               <ul style="list-style-type: none"> <li>• alcohols</li> <li>• alkanes</li> <li>• amines</li> </ul> </li> </ul> Reduction of carboxylic acids, acyl chlorides, esters and anhydrides to primary alcohols. Reduction of acyl chlorides and esters to aldehydes Reduction of nitriles to amines or aldehydes	12. 1-12. 8, 12.12 - 12.15
2A. Mass spectrometry	<ul style="list-style-type: none"> <li>▪ Interaction between radiation energy and matter.</li> <li>▪ Ionization of organic compounds in mass spectrometer.</li> <li>▪ The mass spectrum: molecular ion and structure, base peak, isotopic peaks (<math>M + 2</math>, <math>M + 4</math>, etc.).</li> <li>▪ Identification of halogens and nitrogen in an organic compound from the mass spectrum.</li> <li>▪ Match and identification of structures through the mass spectrum.</li> <li>▪ Most common fragments of some simple molecules (alkanes, alcohols, halides, carbonyl compounds) from their mass spectrum.</li> <li>▪ Determine molecular formulas from the mass spectrum.</li> </ul>	A1-A5
2B. Infrared Spectroscopy	<ul style="list-style-type: none"> <li>▪ Electromagnetic spectrum and relationship of each component with energy, frequency and wavelength.</li> <li>▪ Infrared absorption process - Effect of substituents and symmetry in alkenes and alkynes.</li> <li>▪ Different modes of molecular vibration. Why do several absorptions appear in the spectrum?</li> <li>▪ Hook's Law - Resonance effect, ring tension and hydrogen bonds in the position of absorption of the carbonyl group in aldehydes, ketones, carboxylic acids, esters and amides.</li> <li>▪ Instrument: Basic components of an FTIR with ATR accessory and how the spectrum is taken.</li> <li>▪ The infrared spectrum: what is it?, how is it analyzed?, position, shape and intensity of the absorption bands Correlation table.</li> <li>▪ Correlation of infrared absorption bands and functional groups to match, correlate and identify molecular structures, by means of correlation tables</li> </ul>	B1-B5
3B. Ultraviolet-visible spectroscopy	<ul style="list-style-type: none"> <li>▪ Location of ultraviolet and visible regions in the electromagnetic spectrum. Wavelength range</li> <li>▪ Effect of radiation on organic molecules.</li> <li>▪ The most favorable HOMO-LUMO transitions (<math>\sigma \rightarrow \sigma^*</math>, <math>\pi_n \rightarrow \pi_{(n+1)}^*</math>; <math>n \rightarrow \pi^*</math>; <math>n \rightarrow \sigma^*</math>;) in: alkanes, compounds with double or triple CC bond, saturated compounds with heteroatoms (ROH, ROR, RX, RNH<sub>2</sub>), carbonyl compounds and conjugated molecules.</li> </ul>	14.15

Unit-Topics	Thematic Content	Chapter(sections)
	<ul style="list-style-type: none"> <li>▪ The maximum absorption (<math>\lambda_{\max}</math>) of the most common chromophores and the factors that increase its value: conjugation, substituents and solvent. Calculate the <math>\lambda_{\max}</math> of dienes.</li> <li>▪ Instrument and sample preparation, the molar absorption coefficient (<math>\epsilon</math>) in the UV / Vis spectrum and the application of the Lambert-Beer Law.</li> </ul>	
<b>4. Nuclear Magnetic Resonance</b>	<ul style="list-style-type: none"> <li>▪ Active nuclei and possible orientations against a magnetic field.</li> <li>▪ Phenomenon by which energy absorption occurs and which facilitates the observation of the spectrum.</li> <li>▪ Fundamental equation in NMR.</li> <li>▪ Chemical and magnetic environment.</li> <li>▪ Shielding</li> <li>▪ Chemical shift, internal reference, inductive effects, hybridization, anisotropy, acidity and hydrogen bonds, use of deuterated water.</li> <li>▪ Instrument and its basic components-Solvents and sample preparation.</li> </ul> <p style="text-align: center;"><u>Proton Spectrum -</u></p> <ul style="list-style-type: none"> <li>▪ Graph, scale and correlation table.</li> <li>▪ Number of signals, multiplicity or number of peaks for each signal, application of the n + 1 rule.</li> <li>▪ The integration of signals in the proton spectrum, <math>^1\text{H-NMR}</math>, its calculation and interpretation or prediction.</li> <li>▪ <math>^1\text{H}</math> NMR spectra of the first order for the correlation and determination of simple organic structures (alcohols, ethers, alkyl halides, amines, alkenes and alkynes uncomplicated, carbonyl compounds, benzene derivatives).</li> <li>▪ Match, correlate or calculate the index of hydrogen deficiency (IDH) and determine molecular structures from spectrum by assigning each signal based on integration, multiplicity and chemical shift.</li> </ul> <p style="text-align: center;"><u>Nuclear Magnetic resonance of carbon-13, <math>^{13}\text{C-NMR}</math>.</u></p> <ul style="list-style-type: none"> <li>▪ Differences with protons.</li> <li>▪ Chemical shift, scale and correlation table.</li> <li>▪ Proton-coupled and proton-decoupled <math>^{13}\text{C}</math> spectra.</li> <li>▪ DEPT, importance and advantages over the proton-coupled.</li> <li>▪ Match, correlate or determine molecular structures with the spectrum by assigning each signal, based on multiplicity and chemical shift.</li> <li>▪ Calculate the IDH, propose functional groups, analyze the spectrum (s) and propose the molecular structure through the complementary use of IR, <math>^1\text{H-NMR}</math> and <math>^{13}\text{C-NMR}</math> spectra.</li> <li>▪ Determination of molecular structures from one, two or more of the five possible spectra: MS, IR, <math>^1\text{H-NMR}</math>, <math>^{13}\text{C-NMR}</math> and UV-Visible.</li> </ul>	C1-C12
<b>PARTIAL EXAM # 1</b>		
<b>5. Conjugated Dienes and Diels-Alder reaction</b>	<p style="text-align: center;"><b>Dienes:</b></p> <ul style="list-style-type: none"> <li>▪ Classification, relative stability, conformations and stereochemistry.</li> <li>▪ Classification of conjugated dienes as good, bad, regular and justification.</li> <li>▪ Dienophiles: Classification as good, bad or regular and justification.</li> <li>▪ Conjugated cycloaddition between dienes and dienophiles-Diels-Alder reaction.</li> <li>▪ Mechanism and characteristics of the Diels-Alder.</li> <li>▪ <u>Pericyclic reactions</u>: Definition, classification and examples.</li> <li>▪ Molecular orbitals of dienophiles, dienes, polyenes and representation depending on the number of nodes.</li> <li>▪ Draw all molecular orbitals and identify the frontier ones: HOMO-LUMO in a dienophile, diene, triene, benzene or polyene at room temperature and in an excited state (by photochemistry).</li> </ul>	14.1-14.9, 14.12-14.14 25.1, 25.2, 25.4

Unit-Topics	Thematic Content	Chapter(sections)
	<ul style="list-style-type: none"> <li>▪ Description of Diels-Alder cycloaddition according to the symmetry of the molecular orbitals of the diene and the dienophile. Why should it be thermal and not photochemical?</li> <li>▪ <u>Retrosynthetic analysis</u> to identify the diene and the dienophile.</li> </ul>	
<b>6. Reactions of ethers and epoxides. Organometallic Compounds :</b>	<ul style="list-style-type: none"> <li>▪ Review: Structure and utility including crown ethers.</li> <li>▪ Nomenclature of ethers,</li> <li>▪ Preparation of ethers by the Williamson reaction (<math>S_N2</math>);</li> <li>▪ Reactions (including mechanisms) with hydrogen halides, molecular oxygen;</li> <li>▪ Spectroscopy</li> </ul> <p style="text-align: center;"><b><u>Epoxides:</u></b></p> <ul style="list-style-type: none"> <li>▪ Structure, reactivity, stereochemistry and nomenclature;</li> <li>▪ Preparation with peracids and from halohydrins.</li> </ul>	9. 4 -9.7, 9.1 6- 9.18
<b>7. Introduction to carbonyl compounds and organometallic reagents</b>	<ul style="list-style-type: none"> <li>▪ Synthesis and nomenclature of <math>RLi</math>, <math>RMgX</math> and <math>R_2CuLi</math>.</li> <li>▪ Opening of epoxides with <math>^-OH</math>, <math>H_3O^+</math>, alcohols, organometallic.</li> <li>▪ Coupling reactions with <math>R_2CuLi</math>.</li> <li>▪ Synthesis of alcohols via epoxides and oxidation of these to aldehydes, ketones, carboxylic acids.</li> </ul>	17.1-7.14, 17.16
<b>8. Carbonyl Compounds: Aldehydes and Ketones</b>	<ul style="list-style-type: none"> <li>▪ IUPAC nomenclature of aldehydes and ketones.</li> <li>▪ Relative reactivity's of aldehydes and ketones.</li> <li>▪ Grignard's reaction with aldehydes and ketones.</li> <li>▪ Grignard's reaction with esters</li> <li>▪ Organolithium reagents with carboxylic acids.</li> <li>▪ Aldehyde and ketone reactions: with the hydride ion, with amines and their derivatives, with water, with alcohols: hemiacetals and acetals.</li> <li>▪ Protection of the carbonyl group in organic synthesis.</li> <li>▪ Wittig's reaction.</li> <li>▪ Oxidation and reduction reactions of aldehydes and ketones</li> </ul>	18.1-18.16
<b>9. Carboxylic acids and acidity</b>	<ul style="list-style-type: none"> <li>▪ Structure and bonding of carboxylic acids</li> <li>▪ Nomenclature of carboxylic acids. Important acids (formic, acetic and butyric acid, aspirin, prostaglandins, arachidonic acid)</li> <li>▪ Preparation by carboxylation, oxidation or hydrolysis.</li> <li>▪ Acidity and factors that increase or decrease it in carboxylic acids</li> </ul>	19.1-19. 4, 19. 6 - 19.12
<b>PARTIAL EXAM # 2</b>		
<b>10. Carboxylic acid derivatives and their nucleophilic substitution reactions</b>	<ul style="list-style-type: none"> <li>▪ Definition and structure of the five carboxylic acid derivatives, including the cyclic ones.</li> <li>▪ Relative reactivity between ketone and aldehyde carbonyls and determining factors.</li> <li>▪ IUPAC nomenclature of carboxylic acid acids and derivatives: acyl chlorides, acid anhydrides, esters, amides and nitriles.</li> <li>▪ General mechanism of nucleophilic substitution reactions with acyl derivatives.</li> <li>▪ Preparation of carboxylic acids by carboxylation of organometallic and hydrolysis of nitriles, including the mechanisms of the involved reactions. <ul style="list-style-type: none"> <li>▪ Preparation of acyl chlorides and transformations to anhydrides, esters (phenolic and of any alcohol), amides and carboxylic acids.</li> <li>▪ Anhydride reactions (acidic or basic hydrolysis), with alcohols.</li> <li>▪ Preparation of esters derived from methanol and primary alcohols by the Fischer reaction, and with the alcoholysis of nitriles.</li> <li>▪ Reactions of esters (acid hydrolysis, saponification, alcoholysis or <i>trans</i> esterification,</li> </ul> </li> <li>▪ Structure, reactivity and importance of lactones and their medical applications.</li> <li>▪ Hydrolysis of amides in acidic and basic medium.</li> <li>▪ Structure, reactivity and importance of lactams and their medical applications.</li> </ul>	20.1-20.12, 20.14, 20.16

Unit-Topics	Thematic Content	Chapter(sections)
	<ul style="list-style-type: none"> <li>▪ Important analgesics and anesthetics containing carbonyl group.</li> <li>▪ IR spectroscopy for the 5 carboxylic acid derivatives.</li> <li>▪ Preparation of nitriles by dehydration of primary amides.</li> <li>▪ Reduction of carboxylic acids and their derivatives with lithium tetrahydroaluminate, <math>\text{LiAlH}_4</math> in ether.</li> <li>▪ Synthesize carboxylic acid derivatives by three or four step transformations and applying reactions of alcohols, epoxides, via the Diels-Alder reaction, among others.</li> </ul>	
<b>11. Reactions with alpha carbon</b>	<ul style="list-style-type: none"> <li>▪ The acidic character of alpha hydrogen in carbonyl compounds. Enolization: tautomers keto-enol.</li> <li>▪ Halogenation and alkylation of the carbon alpha of aldehydes and ketones.</li> <li>▪ Enolates of non-symmetric carbonyl compounds (kinetic versus thermodynamic)</li> <li>▪ Racemization in alpha carbon</li> <li>▪ Direct alkylation of enolates – Tamoxifen synthesis</li> <li>▪ Synthesis with the malonic ester for acetic acid derivatives.</li> <li>▪ Synthesis with the aceto acetic ester for acetone derivatives.</li> </ul>	21.1- 21.10
<b>12. Condensation reactions</b>	<ul style="list-style-type: none"> <li>▪ Michael's reaction.</li> <li>▪ Simple and cross aldol reaction.</li> <li>▪ Claisen condensation: simple and crossed.</li> <li>▪ Intramolecular condensation-Dieckmann.</li> <li>▪ Malonic ester synthesis and acetoacetic synthesis for the preparation of carboxylic acids and methyl ketones, respectively.</li> </ul>	22.1 -22.7
<b>PARTIAL EXAM # 3</b>		
<b>12. Amines</b>	<ul style="list-style-type: none"> <li>▪ Classification of amines in primary, secondary, tertiary and quaternary ammonium salts.</li> <li>▪ IUPAC Nomenclature of amines.</li> <li>▪ Preparation of amines</li> <li>▪ Amines as bases and nucleophiles.</li> <li>▪ The Hofmann elimination reaction.</li> <li>▪ Electrophilic substitution with aromatic amines</li> <li>▪ IR and <math>^1\text{H-NMR}</math> spectroscopy.</li> </ul>	23.1 - 23.11
<b>13. Carbohydrates</b>	<ul style="list-style-type: none"> <li>▪ Carbohydrate classification. Series D and L.</li> <li>▪ Configuration of aldoses and ketoses.</li> <li>▪ Stereochemistry of glucose: Fischer and Haworth projections.</li> <li>▪ Hemiacetals and cyclic ketals of monosaccharides: mutarotation.</li> <li>▪ The glycosidic bond, reducing and non-reducing sugars.</li> <li>▪ Disaccharides: maltose, cellobiose, lactose, sucrose. The 1,4'-glycosidic bond.</li> <li>▪ Polysaccharides: starch (amylose and amylopectin), cellulose.</li> <li>▪ Synthesis of Kiliani-Fischer</li> </ul>	26.1- 26.13
<b>14. Amino Acids, Peptides and Proteins</b>	<ul style="list-style-type: none"> <li>▪ Classification and nomenclature of amino acids. Amino acid configuration</li> <li>▪ Acid-base amino acid reactions.</li> <li>▪ The isoelectric point, electrophoresis.</li> <li>▪ Abbreviated and complete structure of a peptide, characteristics of the peptide bond, peptides of interest and medical applications.</li> <li>▪ Protein structure: Primary, secondary, tertiary and quaternary structures.</li> <li>▪ Denaturation.</li> <li>▪ Enzymes and their catalytic action.</li> </ul>	27.1-27.5, 27.9, 27.10
<b>COMPREHENSIVE FINAL TEST: 125 points Topics 1- 11 (70%); 12 -14 (30%) May 30, 2022</b>		



## VI. ACTIVITIES

- Conference
- Board
- Group exercises (2-3) to review the previous class.
- Short tests in person or through Blackboard and /or Connect (McGraw Hill)
- Learn Smart and Prep (Resources through the Connect platform (McGraw Hill))
- Exams
- Participation of students on the whiteboard
- Laboratory experiments
- Practice exercises

## VII. EVALUATION CRITERIA

***All exams and laboratory experiences will be offered in person. Please note that the Blackboard, Respondus, and Connect platforms may be used for course evaluation purposes.***

1. The evaluation of the course consists of:
  - A. A theory part composed of three (3) partial exams, a final exam, short test and assignments. These evaluation criteria correspond to 75% of the final grade.
  - B. A part of experimental practice corresponding to 25% of the final grade which must be approved with a minimum of 60%.

Evaluation criteria	Value	% of final grade
Partial Exam # 1	100	17
Partial Exam # 2	100	15
Partial Exam # 3	100	15
FINAL EXAM Comprehensive	125	18
Assignments in Connect	100	5
Short tests in Connect	100	5
Laboratory	100	25
<b>TOTAL</b>	<b>725</b>	<b>100</b>

2. Access to the Connect Chemistry McGraw Hill platform **is required**. To buy this access you must go to <https://www.universitybookspr.com/universities/titles>. Access to this platform will facilitate compliance with the evaluation criteria: Assignments and Short Tests. Below is the link to access the section of your course in Connect and register.

### **SECTION MONDAYS AND WEDNESDAY (10-12 am) CRN 13866**

<https://connect.mheducation.com/class/l-arias-encarnacion-chem-2222-2022-33-crn-13866-mw-10-12-m>

3. The student will have the opportunity to accumulate up to 5 points taking quizzes and 5 points from assignments through connect. Quizzes will have deadlines and up to 20 minutes to be completed. Assignments won't have time limit but they will have deadline.
4. There will be no double counting of exams, nor special works to substitute deficient results or improve your final average in the course. It is also not required that you present excuses if you do not show up for a partial exam. In that case, what you should do is take care of your personal situation and present yourself during office hours for the reposition, no later than one week after the exam.
5. A poor grade (54 % or less in the conference and 59 % or lower in the laboratory) means the non-approval of the course.
6. The following evaluation scale will be applied in the final grade.

7. Another alternative to accumulate up to 10 points is by participating in the Strengthen Your Science Program, offered through the Faculty of Science and Technology. The points that are reported would be added to the final exam.

100-85 A  
84-75 B  
74-65 C  
64-55 D  
54-0 F

## VIII. EDUCATIONAL RESOURCES

### a) Text book:

Organic Chemistry, Smith J.G. 6<sup>th</sup> Edition, McGraw-Hill Education, **2020**. ISBN: 978-1-260 11910-7.

### b) Manual for the laboratory:

**LABORATORY MANUAL FOR ORGANIC CHEMISTRY II**, L. Arias, and I. Rosado, San Juan, Puerto Rico **VERSION OF FEBRUARY 2022**.

### b) Electronic resources.

1. <http://connect.mheducation.com> (Accessed February 27, 2022)
2. <http://www.prenhall.com/bruice> (Accessed February 27, 2022)
3. For purification techniques and melting points in the lab, nomenclature tutorial, or retrosynthesis <http://www.organicworldwide.net/> (Accessed February 27, 2022)
4. Alkene problems (Accessed February 27, 2022)  
[http://www.uam.es/departamentos/ciencias/qorg/docencia\\_red/qo/l9/reac\\_p.html](http://www.uam.es/departamentos/ciencias/qorg/docencia_red/qo/l9/reac_p.html)
5. Others- Designed and assigned by the instructor

## IX. BIBLIOGRAPHY

### Books

1. Organic Chemistry, Organic Chemistry, P. Y. Bruice, Seventh Edition, Prentice Hall 2014. ISBN 13: 978-0-321-80322-1
2. Organic Chemistry, M. A. Fox and J. K. Whitesell, Tercera Edición, Jones and Bartlett Publishers **2004**. ISBN 0763721972.
3. Advanced Organic Chemistry, F. A. Carey and J. Sundberg, Cuarta Edición, Plenum Publishers 2001. ISBN 00306462443.
4. Advanced Organic Chemistry, March, J. Smith, M. B. Wiley-Interscience, Quinta Edición 2001, ISBN 04715890.
5. Organic Chemistry, P. Y. Bruice, Cuarta Edición, Prentice Hall 2001, ISBN 0130178516.
6. Organic Chemistry, F. A. Carey, McGraw-Hill Science 2002, ISBN 0072521708
7. Organic Chemistry, L. G. Wade and L. G. Jr. Wade, Prentice Hall, Fifth Edition 2002. ISBN 013033832X.
8. Macroscale and Microscale Organic Experiments, Kenneth L. Williamson, D.C. Houghton Mifflin Company, Fourth Edition 2002, ISBN 0618197028.
9. Experimental Organic Chemistry: A Miniscale and Macroscale Approach, J. C. Gilbert, S. F. Martin, Brooks College, Third Edition 2001, ISBN 00303440632.

### Computers with Internet access and programs:

1. ChemDraw/CHEM 3D

2. <http://connect.mheducation.com>

## X. SPECIAL NOTES

### 1. Auxiliary services or special needs

Any student requiring auxiliary services or special assistance must request them at the beginning of the course or as soon as he / she acquires knowledge that he / she needs them, through the corresponding register, in the Orientation Office with Mrs. María de Los Angeles Cabello, Office 111.

### 2. Honesty, fraud and plagiarism

The lack of honesty, fraud, plagiarism and any other inappropriate behavior in relation to academic work constitute major infractions sanctioned by the General Student Regulations. Major infractions, as provided in the General Student Regulations, may result in the suspension of the University for a defined period of more than one year or permanent expulsion from the University, among other sanctions.

### 3. Use of electronic devices

Cell phones and any other electronic device that could interrupt teaching and learning processes or alter the environment conducive to academic excellence will be disabled. The pressing situations will be attended, as appropriate. The use of electronic devices that allow accessing, storing or sending data during evaluations or examinations is prohibited.

### 4. Compliance with the provisions of Title IX

The Federal Higher Education Act, as amended, prohibits discrimination based on sex in any academic, educational, extracurricular, athletic or any other program or employment, sponsored or controlled by a higher education institution regardless of whether it is performed inside or outside the campus of the institution, if the institution receives federal funds. As provided by the current federal regulations, a Title IX Assistant Coordinator has been designated in our academic unit to provide assistance and guidance in relation to any alleged incident constituting discrimination based on sex or gender, sexual harassment or sexual assault. You can contact the Assistant Coordinator, Mr. George Rivera, at (787)250-1912 extension 2262 or 2147 or email [griverar@metro.inter.edu](mailto:griverar@metro.inter.edu). The Normative Document entitled **Rules and Procedures for Addressing Alleged Violations of the Provisions of Title IX** is the document that contains the institutional rules to analyze any complaint filed based on this type of claim. This document is available on the website of the Inter-American University of Puerto Rico ([www.inter.edu](http://www.inter.edu)).

## XI. ETHICAL VALUES

It is expected that 100% of the students show a behavior of total honesty when completing and delivering the assignments and laboratory reports. Plagiarism will not be allowed in any of its modalities, 0% of cases of dishonesty are expected.

**NOTE:** It is important to be clear that the different forms of plagiarism or improper use of works in the laboratory, ideas or words of another person without consent or recognition, is an academic infraction with very serious consequences. See the General Regulations for students of the Inter-American University of Puerto Rico-2004, p.60 and onwards for examples of the types of plagiarism and the sanctions that apply. In this course, this type of practice will be penalized when evaluating your work.