SAGRADO
Universidad del Sagrado Corazón

SCHOOL OF HEALTH AND SCIENCES

SYLLABUS

TITLE:	Organic Chemistry I
CODE:	QUI 301
PREREQUISITE:	QUI 102
CORREQUISITES:	QUI 301L
CREDITS:	4 credits | 45 contact hours | 45 lab hours | 1 term

DESCRIPTION

Study of the atomic and molecular structure of organic compounds. The course covers aspects related to the concept of isomerism, discussing the kinetic and thermodynamic variables that affect organic reactions. Substitution, elimination, and addition reactions and the mechanisms by which these reactions proceed are studied. The physical and chemical properties of alkanes, alkenes, alkynes, alkyl halides, alcohols and ethers are studied. The nomenclature, molecular structure, synthesis, and reactions of compounds belonging to these families are discussed. This course uses web-supported resources, lectures, lab experiences, and teamwork to write a research proposal. This course is aimed at students majoring in Chemistry, and health-allied sciences, trained to understand the biological and industrial processes of the world around us.

JUSTIFICATION

Medicines, textiles, plastics, fuels, food, and biological processes occur in the daily life of human beings. These are examples of the importance of a student training in the natural sciences having knowledge of organic chemistry. The purpose of the course is to train students to understand organic chemistry and thus obtain a basis to be able to understand the processes that occur in biological systems, the environment, and the human body.

COMPETENCES

The course develops the following competences in students:

- **Critical questioning**
- **Research and exploration**

OBJECTIVES

After completion of the course, students will be able to:

1. Explain theories related to the molecular structure of organic compounds.
2. Explain the difference between connecting isomers, enantiomers, and diastereomers.
3. Describe the mechanisms of unimolecular and bimolecular aliphatic nucleophilic substitution reactions and unimolecular and bimolecular deletion reactions and the factors affecting such reactions.
4. Explain the chemical properties of alkanes, alkenes, alkynes, alcohols, and ethers and how they can be used to carry out organic synthesis.

CONTENTS

I. Molecular Structure of Organic Compounds
    A. Atomic structure
        1. Atomic orbitals
        2. Electronic configurations
    B. Covalent bond
        1. Formation of a covalent bond
        2. Lewis structures
        3. Bond length
        4. Bond angle
        5. Resonance
        6. Molecular geometry
            a. Linear
            b. Angular
            c. Trigonal planar
            d. Tetrahedral
            e. Trigonal pyramidal
        7. Dipole moment and molecular structure
    C. Intermolecular forces
        1. London
        2. Dipole-dipole
        3. Ion-dipole
        4. Hydrogen bonding

D. Functional Groups of Organic Compound Families
    1. Alkanes
    2. Alkenes
    3. Alkynes
    4. Cycloalkanes
    5. Alkyl halides
        a. Primary
        b. Secondary
        c. Tertiary
    6. Alcohols
        a. Primary
        b. Secondary
        c. Tertiary
    7. Ethers
    8. Aromatic
    9. Aldehydes
    10. Ketones
    11. Carboxylic acids
    12. Amines
        a. Primary
        b. Secondary
        c. Tertiary
    13. Amides
        a. Primary
        b. Secondary
        c. Tertiary
    14. Esters
    15. Carboxylic anhydrides
    16. Acyl Chlorides
    17. Nitriles
E. Molecular structure of alkanes
    1. Condensed formula
    2. Linear formula

F. Nomenclature
    1. Alkanes & alkyl groups
    2. Cycloalkanes
    3. Bicyclic
G. Newman conformations and projections
    1. Ethane
        a. Staggered
        b. Eclipsed
    2. Butane
        a. Anti
        b. Gauche
        c. Eclipsed
H. Angle strain and conformations in cycloalkanes
    1. Cyclopropane
    2. Cyclobutane
    3. Cyclopentane
    4. Cyclohexane
        a. Chair conformation
        b. Boat conformation
        c. Axial and equatorial positions

II. Isomers and Stereoisomers
A. Definition of the different types of isomers
    1. Connection isomers
    2. Geometric isomers
        a. Cis isomer
        b. Trans isomer
    3. Stereoisomers
        a. Enantiomers
        b. Diastereomers
        c. Meso compounds
B. Optical activity
    1. Polarimeter
    2. Specific Rotation

3. Racemic Mixing

C. R-S assignment to chiral carbon

1. Prioritization
2. Compounds with a single chiral carbon
3. Compounds with two chiral carbons

D. Fischer projection

1. Compounds with a single chiral carbon
2. Compounds with two chiral carbons
    a. Enantiomers
    b. Diastereomers
    c. Meso compounds

III. Organic Reactions

A. Kinetics of a reaction

1. Rate Law
2. Rate constant
    a. Collisions
    b. Collision orientation
    c. Activation energy
    d. Temperature
    e. Arrhenius equation
3. Mechanism of a reaction
    a. S_N2
    b. S_N1
4. Energy contour diagram
    a. Transition state
    b. Intermediate
    c. Hammond's postulate

B. Thermodynamics of a reaction

1. Equilibrium state
2. ΔH, ΔS, ΔG of a reaction
3. Exergonic and endergonic reactions

C. Acids and bases

1. Brønsted-Lowry definition

2. Lewis' definition
3. Acid-base strength
    a. Effect of resonance
    b. Inductive effect
    c. Steric effect
    d. Hybridization effect

D. Classification of reactions
1. Substitution
2. Addition
3. Elimination
4. Rearrangement
5. Oxidation-reduction

E. Bimolecular nucleophilic substitution (S_N2)
1. Substrate
2. Reagent
3. Rate law
4. Factors affecting an S_N2 reaction
    a. Substrate type
    b. Solvent
    c. Nucleophile
    d. Leaving group
5. Stereochemistry of S_N2 reaction
6. Organic synthesis: synthetic use of S_N2

F. Unimolecular nucleophilic substitution (S_N1)
1. Reaction mechanism and its rate law
2. Factors affecting the S_N1 reaction
    a. Substrate type
    b. Solvent
    c. Nucleophile
    d. Leaving group
3. Stereochemistry of the S_N1 reaction
    a. Racemic mixture
    b. Inversion vs retention

G. Bimolecular removal (E2)
    1. Rate law
    2. Factors favoring the E2 mechanism
    3. Stereochemistry
    4. Zaitsev's rule
H. Unimolecular elimination (E1)
    1. Rate law
    2. Factors that favor it
    3. Stereochemistry
I. S_N2 vs. E2 and S_N1 vs. E1

IV. Chemical Properties of Alkane, Alkene, Alkyne, Alcohol, and Ether Families
A. Alkane synthesis and reactions
    1. Alkyl halide reduction
    2. Corey–House synthesis (Corey-Posner–Whitesides-House reaction)
    3. Alkane halogenation
B. Alkenes, alkynes, and conjugated systems
    1. Physical properties of alkenes
    2. Nomenclature of alkenes
        a. Z isomer
        b. E isomer
        c. Cycloalkenes
    3. Stability of alkenes
    4. Stereochemistry of cycloalkenes
    5. Alkene synthesis: dehydration of alcohols
        a. Mechanism
        b. Carbocations migration
    6. Alkene reactions
        a. Electrophilic addition mechanism
            1) electrophile
            2) electrophile vs nucleophile
        b. Markovnikov's rule
        c. Regioselective reaction
        d. Stereochemistry of addition mechanisms

- e. Electrophilic addition reactions
  - 1) Addition of H_2SO_4
  - 2) Addition of H_2O/H^+
  - 3) Addition of halogens
  - 4) Halogenation in water
- f. Regioselective vs stereospecific reaction
- g. Alkene oxidations
  - 1) Syn hydroxylation
  - 2) Ozonolysis
  - 3) Other oxidations

7. Nomenclature of alkynes
8. Physical properties of alkynes
9. Acidity of alkynes
10. 10. Synthesis of alkynes
    - a. Synthesis from alkenes
    - b. Synthesis via $NaNH_2$ combined with S_N2 reaction
11. Alkyne reactions
    - a. Addition of halogens
    - b. Addition of HX
    - c. Alkyne oxidation
    - d. Alkyne hydrogenation
      - 1) Syn addition
      - 2) Anti-addition
12. Conjugated systems
    - a. Classification of dienes and polyenes
      - 1) Conjugated
      - 2) Cumulative
      - 3) Isolated
    - b. Preparation of dienes
    - c. Addition of 1,2 and 1,4 electrophiles to dienes
    - d. Kinetic and thermodynamic control
    - e. Diels-Alder reaction
      - 1) Diene conformation

        2) Donor electron and electron attractant groups
        3) Stereochemistry
        4) Mechanism

C. Alcohols and ethers
    1. Physical properties of alcohols and ethers
    2. Nomenclature of alcohols
        a. Common nomenclature
        b. IUPAC nomenclature
    3. Synthesis of alcohols
        a. Hydration of alkenes
        b. Oxymercuration-demercuration
        c. Hydroboration-oxidation
        d. Grignard reagent
        e. Reduction of aldehydes and ketones
    4. Alcohol reactions
        a. Reactivity of OH group
        b. Acidity of alcohols
        c. Conversion of alcohols to mesylates and tosylates
        d. Mesylates and tosylates in S_N2 reactions.
        e. Alkyl phosphates
        f. Conversion of alcohols to alkyl halides
    5. Nomenclature of ethers
        a. Common ethers
        b. Crown ethers
    6. Ether synthesis
        a. Dehydration of alcohols
        b. Williamson Synthesis
    7. Ether reactions

LAB EXPERIENCES

A. Laboratory safety and Safety Data Sheets
B. Recrystallization and point of fusion (macroscale)
C. Crystallization and point of fusion (microscale)

D. Distillation and boiling point (macroscale)
E. Distillation and boiling point (microscale)
F. Extraction (macroscale)
G. Extraction (microscale)
H. Dehydration of an alcohol
I. S_N2 reaction: Synthesis of 1-bromobutane

METHODOLOGY

The following strategies from the active learning methodology are recommended:

- Written research proposal
- Laboratory
- Solving a problem posed
- Web-supported education
- Literature research
- Simulations
- Lectures
- Collaborative learning and teamwork

EVALUATION

Partial assignments	30%
Compositions	20%
Final project or exam	25%
Immersion experience	25%
Total	**100%**

LEARNING ASSESSMENT

The institutional assessment rubric is applied to the course's core activity.

BIBLIOGRAPHY

TEXTBOOK

Aponte, M., Rivera, Z., & Guntin, M. (2004). *Química Orgánica: Manual de laboratorio* (4th ed.). Librería Universal.

Wade, L.G., Jr., Simek, J. W. (2016). *Organic Chemistry* (9th ed). Pearson.

REFERENCES

Carey, F. (2019). *Organic Chemistry* (11th ed.). McGraw Hill Higher Education.

Karty, J. (2018). *Organic Chemistry: Principles and Mechanisms* (2nd ed.). W. W. Norton& Company.

Klein, D. R. (2016). *Organic Chemistry* (3rd ed.) Wiley.

Klein, D. R. (2016). *Organic Chemistry as a Second Language: First Semester Topics* (4th ed.). Wiley.

Klein, D. R. (2019). *Organic Chemistry as a Second Language: Second Semester Topics* (5th ed.) Wiley.

Mc Murry, J. E. (2015). *Organic Chemistry* (9th ed.). Cengage Learning.

Smith, J. (2018). *General, Organic and Biological Chemistry* (4th ed.) McGraw Hill Higher Education.

Stoker, H. S. (2015). *General, Organic, and Biological Chemistry* (7th ed.). Cengage Learning.

Valiulin, R. (2020). *Organic Chemistry: 100 Must-Know Mechanisms in Organic Chemistry* (1st ed.). De Gruyter.

Yurkanis, P. (2016). *Organic Chemistry* (8th ed.). Pearson.

ELECTRONIC RESOURCES

American Chemical Society. (n.d.). *ACS Chemistry for Life*. https://www.acs.org/content/acs/en.html

International Union of Pure and Applied Chemistry. https://iupac.org/

For more information resources related to the course's topics, access the library's webpage http://biblioteca.sagrado.edu/

REASONABLE ACCOMMODATION

For detailed information on the process and required documentation you should visit the corresponding office. To ensure equal conditions, in compliance with the ADA Act (1990) and the Rehabilitation Act (1973), as amended, any student in need of reasonable accommodation or special assistance must complete the process established by the Vice Presidency for Academic Affairs.

ACADEMIC INTEGRITY

This policy applies to all students enrolled at Universidad del Sagrado Corazón to take courses with or without academic credit. A lack of academic integrity is any act or omission that does not demonstrate the honesty, transparency, and responsibility that should characterize all academic activity. Any student who fails to comply with the Honesty, Fraud, and Plagiarism Policy is exposed to the following sanctions: receive a grade of zero in the evaluation and / or repetition of the assignment in the seminar, a grade of F (*) in the seminar, suspension, or expulsion as established in the Academic Integrity Policy effective in November 2022.