



MEDTEC SHOOL

Course: Chemistry and Organic chemistry

Year (1st-2nd-3rd-4th-5th-6th): 1st

Period (1st-2nd semester – annual): 1st semester

Credits: 6

Objectives

This Course in Chemistry and Organic Chemistry is designed to emphasize the fundamental principles of the science and to reflect its interdisciplinary nature. Because chemistry is the “central” science, a wide variety of opportunities awaits those with training in this field. This Course provides the students with an important background to understand the molecular basis of the bio-medical sciences. The Course offers a program meeting the needs of students who anticipate careers as healthcare professionals in the medical sciences, such as medicine and biomedical research. In particular, the Course aims to provide the students with an introduction to the fundamental concepts required to rationalize and predict molecular structure, molecular interactions, and chemical reactivity. More specifically, the first part of the Course aims to provide the students with an appreciation of the quantum mechanical basis of the Periodic Table and in turn with the ability to explain trends in the chemical behavior of the different elements. The course moves on to provide the students an insight into chemical bonding, from simple inorganic molecules to more sophisticated organic molecules and polymers. Parallel to these components of the Course, an introduction to thermodynamics and kinetics is also provided allowing the students to rationalize and predict chemical reactivity and to study the equilibria in water solutions, with particular emphasis for acid-base and electrochemical equilibria. The second part of the Course dedicated to organic chemistry aims to provide the students with an insight to the principal functional groups, their properties and reactivity on the basis of the knowledge acquired during the first part. Particular attention will be paid on the three-dimensional structure of organic molecules and on those reactions that are fundamental to understand biological processes. An introduction to the structure and chemistry of biopolymers, such as peptides and proteins, carbohydrates, DNA and RNA will be treated to provide the students with a solid background to understand the involvement of such biopolymers in many biological processes. During the Course different multiple-choice tests will be held to provide the students a method of self-evaluation. The relevance of chemistry/organic chemistry to deeply understand biochemical processes will be outlined in planned transdisciplinary lessons.

Prerequisites

Basic knowledge of chemistry concepts at high-school level that include the structure and periodic properties of the atoms, ionic and covalent bonds, relative atomic and molecular mass, and the concept of mole could be helpful, even if not mandatory. Basic knowledge of mathematics and physics is considered as prerequisites.

Contents

1. INTRODUCTION TO CHEMISTRY AND THE ATOMIC STRUCTURE (Week 1, 4h lesson, 2h exercises)

The classification of Matter: physical and chemical properties



Microscopic characteristic of Matter: atoms and molecules

Chemical reactions and mole

Introduction to the Periodic Table

Bohr's theory and quantum numbers

The dual nature of electrons: Schrodinger equation and atomic orbitals

Building-up the electron configuration

Periodic properties of the elements

2. CHEMICAL BONDING (**Week 2, 4h lesson and 2h exercises**)

Valence bond theory and Lewis structures

Electronegativity

Hybridization of atomic orbitals and molecular geometry

Molecular orbital theory

3. STATES OF MATTER (**Week 3, 4h and 2h exercises**)

Intermolecular interactions

Gas: ideal gas model and ideal gas equation

Liquid: vapor pressure and surface tension

Solid: classification and properties

Phases changes and phases diagrams

4. THERMOCHEMISTRY AND SOLUTIONS (**Week 4, 4h lesson and 2h exercises**)

Enthalpy in chemical reactions

Entropy in chemical reactions

Gibbs free energy in chemical reactions

Reaction spontaneity

Molecular view of the solution formation

Concentration units

Colligative properties of nonelectrolytes and electrolytes solutions

5. CHEMICAL EQUILIBRIUM AND CHEMICAL KINETICS (**Week 5, 4h lesson and 2h exercises**)

Concept of equilibrium and equilibrium constants

Factors that affect the chemical equilibrium

Homogenous and heterogeneous equilibrium



Collision theory and rate of a reaction

Activation energy and reaction mechanism

The rate law

Factors that affect the kinetic of a reaction: catalysis

The relationship between chemical equilibrium and chemical kinetic

6. IONIC EQUILIBRIA IN WATER, PART I: ACIDS AND BASES (Week 6-7, 6h lesson and 2h exercises)

Bronsted and Lewis acids and bases

Strength of acids, bases, and ionization constants

pH

Buffer solutions

Hydrolysis and solubility

7. IONIC EQUILIBRIA IN WATER, PART II: ELECTROCHEMISTRY (Week 7-8, 4h lesson and 2h exercises)

Redox reactions

Galvanic cells

Standard reduction potential and battery Emf

Electrolysis

8. INTRODUCTION TO ORGANIC CHEMISTRY AND HYDROCARBONS (week 9, 5h lesson and 1h exercises)

Classes of organic molecules: functional groups

Alkanes, Alkenes, Alkynes, and Aromatic Compounds: nomenclature, physical properties and reactivity

9. STEREOISOMERISM AND ALKYL HALIDES (week 10, 5h lesson and 1h exercises)

Chirality and stereocenters

Enantiomers and diastereoisomers

Halo alkanes: nomenclature, physical properties and reactivity

10. FUNCTIONAL GROUPS CONTAINING C-O AND C-S SINGLE BONDS (week 11, 2h lesson and 1h exercises)

Alcohols: nomenclature, physical properties and reactivity

Ethers: nomenclature, physical properties and reactivity

Thiols, sulfides and disulfides: nomenclature, physical properties and reactivity

11. THE CARBONYL GROUP (week 11, 2h lesson and 1h exercises)

Carbonyl compounds: nomenclature, physical properties and reactivity



12. AMINES (week 12, 2h lesson and 1h exercises)

Amines: nomenclature, physical properties and reactivity

13. THE CHEMISTRY OF AROMATIC COMPOUNDS (week 12, 2h lesson and 1h exercises)

Chemistry of substituted aromatic compounds

Introduction to aromatic heterocycles

14. CARBOXYLIC ACIDS AND DERIVATIVES (week 13, 2h lesson and 1h exercises)

Carboxylic acids: nomenclature, physical properties and reactivity

Esters: nomenclature, physical properties and reactivity

Amides: nomenclature, physical properties and reactivity

15. INTRODUCTION TO BIOPOLYMERS (week 13, 2h lesson and 1h exercises)

Saccharides: structure, properties and chemistry

Peptides and proteins: structure and properties

Nucleic acids: classification, structure and properties

Teaching Methods

The course foresees frontal theoretical lessons and exercises. At the end of any topics a multiple-choice test will be held to provide the students a method of self-evaluation. Moreover, two transdisciplinary lessons will be organized with the teacher of the Biochemistry Course in order to highlight the relevance of chemistry/organic chemistry to deeply understand biochemistry and to stimulate the curiosity among the connection between two disciplines. Students are encouraged to actively participate to the lectures with questions and comments. If possible according to the availability of the didactic laboratory at Department of Chemistry, Material and Chemical Engineering, Politecnico di Milano, a half day chemical workshop will be organized.

Verification of learning

The exam consists of a written test and an oral discussion. The written test is composed of 10 exercises/open questions on the whole program with a maximum mark of 33/30. The written test will be the subject of the oral discussion for those students with a written evaluation starting from 18/30. The exam may be taken in February (two separate tests), or July (two tests) or September (one test).

Texts

Janice G. Smith, **GENERAL, ORGANIC, & BIOLOGICAL CHEMISTRY**. 4th Edition. McGRAW-HILL

This text must be integrated with notes



Raymond Chang, Kenneth A. Goldsby, **GENERAL CHEMISTRY** – The essential concepts. 7th Edition.
McGRAW-HILL International 2014

This text is a comprehensive text for General Chemistry

Janice G. Smith, **ORGANIC CHEMISTRY**. 6th Edition. McGRAW-HILL

This text is a comprehensive text for Organic Chemistry

Slides and exercises will be available on Beep site.