Corso di Laurea Magistrale
in
CHEMISTRY

Manifesto degli Studi

Anno Accademico 2022-2023

Approvato dal Consiglio di Dipartimento di Chimica e Tecnologie Chimiche in data 18 Marzo 2022

Denominazione del Corso di Studio	**CHEMISTRY**
Denominazione in inglese del Corso di Studio	**CHEMISTRY**
Anno Accademico	**2022-2023**
Classe di Corso di Studio	**LM-54**
Dipartimento	**CHIMICA E TECNOLOGIE CHIMICHE**

Contenuti del Manifesto degli Studi

OFFERTA DIDATTICA PROGRAMMATA - COORTE A.A.2022/2023

1. Il Corso di Studi in breve (Brief Presentation)

The MSc Degree in Chemistry aims to develop chemists who can use chemistry to ingeniously optimize, conserve and render sustainable, the wealth of resources at the heart of the Mediterranean.

The MSc Degree course offers two curricula:

- **Chemistry of Environment, Health and Local Resources**: theoretical and practical applications of advanced methods of chemical analysis; processes of transport and diffusion of substances; modern methodologies and techniques in applied analytical chemistry (*e.g.* for quality control of foods, soils, industrial waste, *etc*.).
- **Chemistry of Sustainable Materials**: environmentally friendly organic synthesis methods; metal catalysis; smart materials; spectroscopic and diffractometric analysis of materials; synthesis of functional materials.

Learning objectives and outcomes

- Mastery of advanced-level knowledge and laboratory skills in chemistry;
- Creatively apply advanced knowledge and skills to solve problems in environmental chemistry, chemistry of materials and chemical issues in the life sciences;
- Design and safely operate environmentally sustainable processes;
- Apply understandings of molecular structures and interactions to monitor and shape macroscopic properties;
- Communicate effectively about chemistry knowledge and processes, both orally and in writing.

- Delineate chemical solutions to local issues such as the optimization of local agro-food resources and reuse of waste materials of local industries.

Main topics

- Analytical Methods for Environment, Health and Agro-food Products
- Environmental Physical Chemistry
- Molecular and Nanostructured Materials
- Chemistry of Organic Materials
- Analytical Chemistry for Materials
- Materials and Devices for Renewable Energy
- Structure and Intermolecular Interactions
- Catalysis and Sustainable Chemistry

Employability and careers

- Analysis laboratories in public or private health structures
- Research & Development and/or Production & Control of new materials in chemistry-specific sectors such as pharmaceutics, cosmetics, construction, textile laboratories, etc.
- Research & Development in other enterprises/corporations;
- Education.

Graduates from the Master in Chemistry LM-54 are expected to use Italian, plus at least one additional EU language such as English fluently, to communicate disciplinary knowledge. For foreign students, the University provides free Italian courses which also qualify as elective coursework.

2. Piano di studio ufficiale per studenti impegnati a tempo pieno (Course Catalogue)

CURRICULUM # 1 – CHEMISTRY OF ENVIRONMENT, HEALTH AND LOCAL RESOURCES											
Year	Sem.	Course	*Attività formativa*	*Ambito disciplinare*	*SSD*	ECTS	Lectures	Tutorial	Lab.	Total ECTS per sem.	Total ECTS per year
1°	I	Applied Analytical Chemistry	*Caratterizz.*	*Chimiche analitiche e ambientali*	*CHIM/01*	**6**	*5*		*1*	30	57
		Advanced Organic Synthesis	*Caratterizz.*	*Chimiche organiche e biochimiche*	*CHIM/06*	**9**	*6*		*3*		
		Advanced Inorganic Chemistry	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/03*	**6**	*4*		*2*		
		Advanced Physical Chemistry	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/02*	**9**	*5*		*4*		
	II	Biochemistry	*Caratterizz.*	*Chimiche organiche e biochimiche*	*BIO/10*	**6**	*5*		*1*	27	
		Physical Chemistry Methods for Health and Food Sciences	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/02*	**9**	*5*		*4*		
		Bioanalytical Chemistry	*Affine/Int.*		*CHIM/01*	**6**	*3*		*3*		
		Elective				**6**					
2°	I	Analytical Methods for Environment and Health	*Affine/Int.*		*CHIM/01*	**6**	*4*		*2*	33	63
		Environmental Physical Chemistry	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/02*	**6**	*4*		*2*		
		Computational Methodologies for Environment and Health	*Affine/Int.*		*CHIM/03*	**9**	*5*		*4*		
		Applied Mass Spectrometry	*Caratterizz.*	*Chimiche organiche e biochimiche*	*CHIM/06*	**6**	*4*		*2*		
		Elective				**6**					
	II	Traineeship				**6**				30	
		Thesis				**24**					

CURRICULUM # 2 – CHEMISTRY OF SUSTAINABLE MATERIALS											
Year	Sem.	Course	*Attività formativa*	*Ambito disciplinare*	*SSD*	ECTS	Lectures	Tutorial	Lab.	Total ECTS per sem.	Total ECTS per year
1°	I	Applied Analytical Chemistry	*Caratterizz.*	*Chimiche analitiche e ambientali*	*CHIM/01*	**6**	*5*		*1*	30	57
		Advanced Organic Synthesis	*Caratterizz.*	*Chimiche organiche e biochimiche*	*CHIM/06*	**9**	*6*		*3*		
		Advanced Inorganic Chemistry	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/03*	**6**	*4*		*2*		
		Advanced Physical Chemistry	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/02*	**9**	*5*		*4*		
	II	Biochemistry	*Caratterizz.*	*Chimiche organiche e biochimiche*	*BIO/10*	**6**	5		1	27	
		Chemistry of Molecular and Nano-Materials	*Affine/Int.*		*CHIM/03*	**6**	*4*		*2*		
		Catalyis and Sustainable Chemistry	*Caratterizz.*	*Chimiche organiche e biochimiche*	*CHIM/06*	**9**	*6*		*3*		
		Elective				**6**					
2°	I	Chemistry of Organic Materials	*Affine/Int.*		*CHIM/06*	**6**	*4*	*1*	*1*	33	63
		Analytical Chemistry for Materials	*Affine/Int.*		*CHIM/01*	**6**	*3*		*3*		
		Energy Materials and Devices	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/02*	**6**	*4*		*2*		
		Structural Chemistry by Diffraction Methods	*Caratterizz.*	*Chimiche inorganiche e chimico-fisiche*	*CHIM/03*	**9**	*5*		*4*		
		Elective				**6**					
	II	Traineeship				**6**				30	
		Thesis				**24**					

3. Declaratorie delle singole attività formative (Courses Contents)

Course	**APPLIED ANALYTICAL CHEMISTRY**
SSD	**CHIM/01 (Analytical Chemistry)**
Content	• Extraction of semi-volatile organics from liquids; • Extraction of semi-volatile organic compounds from solid matrices; • Extraction of volatile organic compounds from solids and liquids; • Preparation of samples for metals analysis; • Validation of an analytical method.
Learning objectives and outcomes	Students will know how to prepare samples for qualitative and quantitative analyses; be able to identify acceptable analytical parameters; know how to choose and assess the critical steps and appropriate operating conditions for obtaining reliable analytical measurements.
ECTS	6

Course	**ADVANCED ORGANIC SYNTHESIS**
SSD	**CHIM/06 (Organic Chemistry)**
Content	Electrocyclic reactions; advanced stereochemistry; retrosynthetic analysis; rearrangement reactions in organic chemistry. Laboratory involves the synthesis of five organic compounds and their characterization using GC-MS and ^{1}H-NMR.
Learning objectives and outcomes	Students will acquire in-depth knowledge in organic chemistry for identifying the optimal conditions for obtaining specific products, especially with regard to stereoselective processes.
ECTS	9

Course	ADVANCED INORGANIC CHEMISTRY
SSD	CHIM/03 (Inorganic Chemistry)
Content	Part 1 (Reactivity): • This part of the course will cover the reactivity of transition metal complexes in general, with special attention to organometallic complexes. Several classes of organometallic complexes and their general reactions will be outlined. The role of metal complexes as homogeneous catalysts will be defined and a few processes discussed. Part 2 (Theoretical Methods): • Introduction to theoretical and computational chemistry methods in inorganic chemistry. Application of computational methods to case studies concerning organometallic complexes.
Learning objectives and outcomes	Students will gain knowledge regarding the reactivity of complexes in fundamental processes. In-depth study of the nature of the metal-carbon bond in complexes of transition elements. Study of important classes of organometallic complexes and their potential applications with particular regard to applications in homogeneous catalysis. Acquisition of the knowledge necessary for applying theoretical and computational methods in Inorganic Chemistry and of the cognitive tools necessary for understanding the relationships between the electronic structure of model compounds and their physico-chemical properties and reactivity.
ECTS	6

Course	ADVANCED PHYSICAL CHEMISTRY
SSD	CHIM/02 (Physical Chemistry)
Content	Thermodynamics of phase equilibria and phase transitions. Colloids, surfaces and interfaces. Fundamental aspects of the processes that govern the transfer of matter and energy. Spectroscopic methods: molecular and nuclear aspects. Advanced NMR techniques and experimental approaches for structural elucidation of complex materials. Principles of optical and Scanning Electron microscopy (SEM), Atomic Force Microscopy (AFM), SEM experiments.
Learning objectives and outcomes	Students will acquire a detailed basic knowledge of the physical properties of: a) pure substances and mixtures; b) colloidal suspensions and surface properties; c) materials through spectroscopic methodologies. Furthermore, the course aims to provide students with the knowledge and skills regarding fundamental aspects of matter, energy and moment transport processes. Laboratory: at the end of the course students will acquired advanced concepts of main spectroscopic techniques and will be able to apply them to the chemical characterization of matter in its various phases.
ECTS	9

Course	BIOCHEMISTRY
SSD	BIO/10 (Biochemistry)
Content	Structure, function and basic metabolic pathways of principle biological molecules (proteins, carbohydrates, lipids, nucleic acids). Methods of analysis of biological macromolecules. Reactive oxygen species and cellular mechanisms against oxidative stress. Metabolism and detoxification of xenobiotics.
Learning objectives and outcomes	The course aims to provide students with fundamental biochemical and biological knowledge essential for understanding both the composition and the basic structural and functional mechanisms of living organisms in relation to drug development and the interaction between humans and pollutants.
ECTS	6

Course	PHYSICAL CHEMISTRY METHODS FOR HEALTH AND FOOD SCIENCES
SSD	CHIM/02 (Physical Chemistry)
Content	The course aims to integrate the theoretical and experimental knowledge regarding modern physical-chemical methods applied to medical imaging technology and food sciences, with particular emphasis on green and sustainable developments. The course will cover a range of topics, from medical imaging, such as advanced tomographic techniques and NMR imaging, to metabolic analyses of biological fluids/tissues and foods, to rheological and spectroscopic analyses of food products.
Learning objectives and outcomes	The objective of this course is to provide an in-depth understanding of the physical phenomena underlying modern imaging and non-imaging technologies currently used in the field of medical diagnosis and in food characterization and safety. Students will be able to apply their chemical-physical knowledge to identify which techniques are suitable for obtaining the information sought, and the advantages/disadvantages of each technique. Furthermore, students will be able to appropriately handle and correlate information from different techniques and experiments.
ECTS	9

Course	BIOANALYTICAL CHEMISTRY
SSD	CHIM/01 (Analytical Chemistry)
Content	Basic concepts and biosensor definitions: biosensors based on enzymatic and immunochemical reactions with electrochemical and spectroscopic transducers. Applications to analysis in biological systems: qualitative/quantitative determination of proteins, amino acids, enzymes in biological fluids. Electrophoresis: basic principles of separation: planar and capillary electrophoresis. Mono- and bi-dimensional electrophoretic methods for the separation and identification of proteins Mass spectrometry (MALDI-MS). Application to the analysis of proteome of animal or plant origin. TOP DOWN and BOTTOM UP proteomic approach in the characterization of food matrices. Bibliographic research and use of databases.
Learning objectives and outcomes	The general objective of the course is to introduce students to the operating principles of the principal sensors and biosensors widely used in many scientific and application contexts. Furthermore, students will gain knowledge regarding the principal and most common analytical techniques used in the analysis of biomolecules. The course is structured in such a way as to allow the acquisition of the indispensable tools for designing experimental protocols for identifying and characterizing proteins in biological and nutritional contexts, which can be used in clinical analyses for the identification of metabolites or markers of pathologies related to food, as well as instrumental control processes in food production and storage.
ECTS	6

Course	ANALYTICAL METHODS FOR ENVIRONMENT AND HEALTH
SSD	CHIM/01 (Analytical Chemistry)
Content	Introduction to chemometrics and its applications in food and clinical fields, environmental sampling design and techniques, Quality Assurance/Quality Control of environmental analysis, wet chemical methods in environmental laboratories, elemental speciation in clinical sciences and application in clinical studies, detection of drugs in biological fluids for antidoping control, applications of LC-MS/MS in clinical laboratory diagnostics.
Learning objectives and outcomes	Students will acquire the fundamental concepts of multivariate data processing and applications of chemometrics. Students will be able to plan the sampling techniques according to the matrices being sampled, the most used analytical approaches for environmental analysis, for doping control, for the speciation of metals and the analysis of metabolites in biological fluids.
ECTS	6

Course	ENVIRONMENTAL PHYSICAL CHEMISTRY
SSD	CHIM/02 (Physical Chemistry)
Content	Introduction to environmental chemistry and its relation to sustainability and green chemistry. Atmospheric composition, atmospheric layers and basic physics. Atmospheric radiation and photochemistry. The chemistry of the stratosphere. Mechanisms related to stratospheric ozone depletion. The chemistry of the troposphere. The chemistry of ground-level air pollution: photochemical smog, acid rains, particulate matter. Aquatic chemistry. Composition of surface and groundwaters. Dissolved carbon dioxide. Alkalinity, acidity and acid/base neutralizing capacity. Equilibrium with solid carbonate. The solid-solution interface. Adsorption isotherms and adsorption kinetics
Learning objectives and outcomes	Familiarize students with the various divisions of the environment and understand the impact that anthropogenic activities have on the environment. Explain atmospheric gaseous composition, vertical variations in atmospheric temperature and pressure. Apply the theories of thermodynamic and chemical kinetics to explain the chemistry of the atmosphere and the mechanisms related to variation of its composition due to natural processes and pollution. Apply chemical equilibrium and chemical kinetics to understanding the processes controlling the chemical composition of aquatic environments and to understand the fate of pollutants in aquatic environments. Laboratory: Sampling of surface water and analyzing its main inorganic composition using ion chromatography and analyzing for the presence of trace elements using inductively coupled plasma mass spectrometry. Design and perform an adsorption experiment and acquire kinetic and isotherm data to be fitted by appropriate theoretical models.
ECTS	6

Course	COMPUTATIONAL METHODOLOGIES FOR ENVIRONMENT AND HEALTH
SSD	CHIM/03 (Inorganic Chemistry)
Content	The aim of the course is the introduction of modern computational methods both quantum-mechanical and non, able to simulate small, medium and large complex systems from both the static and dynamic points of view. In particular, the base of the most important approaches will be presented. Applications will deal with gas-phase and condensed-phase simulations of chemical and biochemical systems of interest for the environment and health.
Learning objectives and outcomes	The objective of this course is: a) to become familiar with modern molecular modeling through computational methods based on classical physics; b) characterize the static and dynamic properties of complex systems of variable dimensions; c) learn how to do a bibliographic search and use the available databases.
ECTS	9

Course	APPLIED MASS SPECTROMETRY
SSD	CHIM/06 (Organic Chemistry)
Content	1. Principles of mass spectrometry. Basic principles of mass spectrometry, description of hardware setup: ion sources, analyzers, detectors, and inlet systems. 2. Applications of mass spectrometry. Applications for controlling the quality, safety and origin of food products; applications for health, environment and forensics. 3. Experiments related to mass spectrometers. Setup of instrumental methods and the determination of quality markers in typical local foods.
Learning objectives and outcomes	The course aims to provide in-depth knowledge of the main mass spectrometry techniques used in environmental, food and clinical analysis laboratories. Students will be able to apply the knowledge of mass spectrometry: i) for the structural determination of natural molecules; ii) for protein sequencing; iii) in field of clinical analyses.
ECTS	6

Course	CHEMISTRY OF MOLECULAR- AND NANO-MATERIALS
SSD	CHIM/03 (Inorganic Chemistry)
Content	- Light-matter interaction processes - Molecular materials: basic concepts of molecular photophysics and their applications - Nanomaterials: synthesis of nanostructured materials; optical properties of metallic nanoparticles (plasmonics) - Applications in medicine (theranostics and drug delivery) and energy transducers devices
Learning objectives and outcomes	The course aims to provide in-depth knowledge of the basic concepts of nanotechnology applied to organic/inorganic hybrid materials, nanostructure-property correlations, and the main applications of nanotechnology in sustainable chemistry.
ECTS	6

Course	CATALYSIS AND SUSTAINABLE CHEMISTRY
SSD	**CHIM/06 (Organic Chemistry)**
Content	1. General concepts in catalysis 2. Catalytic reactions in Organic Chemistry 3. Catalysis for Sustainable Chemistry 4. Laboratory experiments
Learning objectives and outcomes	Students will understand the fundamental aspects of catalytic reactions and their applications in modern organic synthesis, with particular reference to sustainable processes and green chemistry for the production of innovative materials.
ECTS	9

Course	CHEMISTRY OF ORGANIC MATERIALS
SSD	**CHIM/06 (Organic Chemistry)**
Content	Chemistry of organic polymeric materials: synthesis, reactivity and application
Learning objectives and outcomes	The course aims to provide knowledge on the synthesis of advanced organic materials, with reference to polymerization and formulation techniques.
ECTS	6

Course	ANALYTICAL CHEMISTRY FOR MATERIALS
SSD	**CHIM/01 (Analytical Chemistry)**
Content	The course provides an overview of the main instrumental analytical techniques used in the analysis and characterization of materials. New smart materials (SMART) and related analytical applications will also be studied. Laboratory will concern the use of analytical methodologies for the compositional analysis of materials and the design of biomaterials aimed at analytical applications in natural matrices.
Learning objectives and outcomes	Students will understand the main analytical methodologies and spectroscopic techniques used for characterizing materials and biomaterials. In addition, students will know how to choose the most suitable approach for solving analytical problems.
ECTS	6

Course	ENERGY MATERIALS AND DEVICES
SSD	CHIM/02 (Physical Chemistry)
Content	The course aims to provide in-depth training on energy issues related to energy production and energy saving. Hydrogen and lithium, the two chemical elements which represent the "engine" of green energy, will be critically evaluated. Particular attention will be given to fuel cells (PEMFCs) as electrochemical energy production/conversion devices by employing "green hydrogen", and lithium batteries (and post-lithium batteries) as storage devices. The course will focus on materials involved in these areas, treating in a theoretical and practical way, the preparation, properties and applications of materials in the energy sector. Finally, some important characterization methodologies will also be undertaken to study and evaluate the materials.
Learning objectives and outcomes	Students will be familiar with issues related to hydrogen and lithium, which represent the future of green energy and will have basic knowledge regarding electrochemistry, electrode processes and ion transport in electrolytes. The skills that will be acquired are focused on various types of materials, from organic and inorganic hybrid materials to functionalized polymers for applications in energy devices. Students will know how to evaluate the feasibility of an electrochemical process with particular reference to the choice of materials in the energy field, fuel cells and batteries.
ECTS	6

Course	STRUCTURAL CHEMISTRY BY DIFFRACTION METHODS
SSD	CHIM/03 (Inorganic Chemistry)
Content	Structural determination of crystalline and semi-crystalline materials, using main X-ray diffraction techniques. Single crystal diffraction experiments and structural determination by various methods; analysis of structural parameters for the comprehension of structural/properties relationships, particularly regarding transition metal complexes. Fundamentals regarding intermolecular interactions in complex systems. X-ray powder diffraction for microcrystalline and semi-crystalline materials: from sample preparation to analysis of bulk, thin films and nanoparticle sample pattern treatment, indexing, phase identification, crystallite size analysis.
Learning objectives and outcomes	By learning the techniques and methods related to the structural determination of solid compounds using X-ray instruments, students will understand the fundamental relationship between the submicroscopic structure of the material and their chemical as well as physical macroscopic properties.
ECTS	9