UNIVERSITA' DEGLI STUDI DI NAPOLI FEDERICO II
POLYTECHNIC AND BASIC SCIENCES SCHOOL

MASTER'S DEGREE IN CHEMICAL SCIENCES

DEPARTMENT OF CHEMICAL SCIENCES

MONTE SANT'ANGELO UNIVERSITY CAMPUS

http://www.scienzechimiche.unina.it/LMSC/

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General information on the Degree Programme

The Master's Degree Course in Chemical Sciences aims to provide graduates with a high level of preparation in the various sectors of chemistry and a high mastery of the scientific method of investigation, through an educational offer that adapts to the student's educational needs and the demands of the world of work.

The course of study is divided into 2 curricula, "Scienze Chimiche" and "Chemical Sciences", distinguished by the language of delivery and by the integrated laboratory courses, differering also for related and supplementary courses.

The training course includes **a first block of courses** common to all students, which completes and expands the training in the fundamental chemical disciplines (Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Analytical Chemistry, Biochemistry), which includes laboratory courses divided into 5 paths (for each curriculum). **A second block of courses** (related courses and courses at student's choise) allows students to acquire interdisciplinary knowledge in the most updated experimental and theoretical methodologies of design, analysis and synthesis applied to specific areas of particular relevance and actuality, such as chemistry for the environment and cultural heritage, forensic chemistry, sustainable energy, chemistry of biomolecules, structural modelling and characterisation methodologies with different resolution scales, or innovative synthesis and catalysis methodologies.
Modern, safe and well-equipped laboratories are available for the courses and the degree thesis.
The inclusion by the MUR of the Department of Chemical Sciences of Unina among the 180 Departments of Excellence for the five-year period 2023-2027 is the premise for further development of teaching in the years to come.
Master's Degree Course in Chemical Sciences has the European recognition "**Chemistry Euromaster Label**". The credits earned by the Master's Degree Graduate can therefore be spent at European level, ensuring maximum mobility in the international university space.

Career opportunities

Master's Degree Graduates in Chemical Sciences have adequate skills and abilities both for continuing their studies in **PhD** or **Master**'s courses, and for validly entering all sectors of the **chemical industry** or **public bodies** or **research** facilities or **analysis** laboratories.
The Master's Degree graduate will be able to carry out his or her activity in both public and private institutions and companies, not only as an employee but also as **a freelance consultant**, after obtaining the title of **Chemist** through the state exam.
The course prepares for the professions of:

- Chemists and similar professions - (ISTAT Code 2.1.1.2.1)
- Chemists, informants and popularizers - (ISTAT Code 2.1.1.2.2)
- Researchers and technicians graduated from the university - (ISTAT Code 2.6.2)
- Researchers and technicians graduated in chemical and pharmaceutical sciences - (ISTAT Code 2.6.2.1.3)

Other possible occupations are in the **teaching** -after obtaining the appropriate qualification - and **marketing** fields**.**

Knowledge required for access: terms and admission procedures

To be admitted to the Master's Degree Course in Chemical Sciences, students must have a degree in class L-27 (Chemical Sciences and Technologies, Ministerial Decree 270/04) or L-21 (Chemical Sciences and Technologies, Ministerial Decree 509/99) or other degrees that involve the acquisition of at least 20 credits of courses in the fields of mathematics, physics and computer science, and at

least 30 credits of courses in chemical disciplines, with particular, but not exclusive, reference to the sectors CHEM-01/A, CHEM-02/A, CHEM-03/A, CHEM-05/A and BIOS-07/A.
In the case of students graduates in foreign universities, the adequacy of curricular requirements is assessed on the basis of the programmes carried out in the subject areas that provide the necessary basis for attending the course of study. A knowledge of the **English language of level B1** is also required to enrol in the **curriculum in Italian** and level **B2** to enrol in the **curriculum in English**.
In addition to the possession of the curricular requirements, the verification of the adequacy of personal preparation is required, which is carried out according to the procedures indicated on the WEB page of the Course of Study (**www.scienzechimiche.unina.it/lmsc** and during orientation meetings.

THE EDUCATIONAL PATH

The regular duration of the course of study is 2 years, corresponding to 120 credits, with the educational activities divided as follows:

I year (58-60 CFU) 🕮
From 3 to 8 core courses
From 0 to 2 related/supplementary courses
From 0 to 2 elective courses
English Language Laboratory (B2 level)

II year (60-62 CFU) 🕮
Completion of the 8 characterizing courses
Completion of the 2 courses of a similar/supplementary type
Completion of the 2 elective courses
Internship and orientation activities
Activities for the preparation of the experimental thesis + Degree exam

Master's Degree in Chemical Sciences

To meet the needs of some students who, for personal reasons, believe that they cannot complete the cycle of study within the two academic years, it is possible to select, at the time of enrolment, a course of study divided into 4 years (Part-time contract).
Detailed information on these methods can be found on the website at: www.scienzechimiche.unina.it or can be requested by email from the coordinator (*ccdscienzechimiche@unina.it*).

The Degree Course is divided into two curricula, called ***Scienze Chimiche*** and ***Chemical Sciences***, distinguished by the language of delivery and the contents of some courses. The details of each pathway (Manifesto degli Studi) for the academic year 2025-26 are shown below.

TRAINING PATH
Curriculum Chemical Sciences
A.A. 2025/2026
NB: all courses are taught in Italian

TEACHINGS	ECTS	Teachers	ECTS/ module	SSD	Activities (*)
Advanced Organic Chemistry *(I semester)*	6	D. Montesarchio	6	CHEM-05/A	m
Higher Inorganic Chemistry *(I semester)*	6	A. Lombardi	6	CHEM-03/A	m
Advanced Analytical Chemistry *(I semester)*	6	C. Manfredi	6	CHEM-01/A	m
Complements of Physical Chemistry *(I semester)*	6	N. Rega	6	CHEM-02/A	m
Advanced Biochemistry *(I semester)*	6	A. Piscitelli	6	BIOS-07/A	m
Integrated Laboratories (Tables A.2.1-A.2.5) *(II semester)*	18		3	BIOS-07/A CHEM-01/A CHEM-02/A CHEM-05/A CHEM-03/A	m
Related/supplementary courses (Tab. A3)	12		6	BIOS-07/A BIOS-08/A CHEM-01/A CHEM-01/B CHEM-02/A CHEM-03/A CHEM-04/A CHEM-05/A	r/s
Elective educational activities (Table A.4)	12		6		o
English Language Workshop	4				m
Internship and orientation activities	6				m
Experimental activity for the preparation of the Master's Degree thesis	6+31				m
Master's Degree Exam	1				m
TOTAL	**120**				

Legend of activities: m= mandatory; r/c= related/complementary; o= optional.

The course of study includes ***5 paths consisting of 3 laboratory courses***, to ensure that all students complete the compulsory training required by the LM-54 degree class. In order to customize his/her educational path, the student enrolled in the "Scienze Chimiche" curriculum must compulsorily select 1 path among those listed in tables A.2.1 to A.2.5, dividing the respective exams of his/her choice between the first and second year, until the completion of the 18 credits reserved for them. It should be noted that these courses are integrated*, i.e.* they consist of two modules of 3 credits that must be followed together and correspond to a single exam.

Table A.2.1: Laboratory Core Courses - Track 1

Teachings	Modules	SSD	Teachers	ECTS
Solid-state and in solution structural characterization	Solid State Structural Characterization	CHEM-03/A	F. Borbone	3
	In solution characterization	CHEM-01/A	A. Amoresano	3
Proteomics and metabolomics	Proteomics	BIOS-07/A	F. Cozzolino	3
	Analytical methods in metabolomics	CHEM-01/A	A. Amoresano	3
Molecular spectroscopy methods	NMR Spectroscopy Laboratory	CHEM-05/A	R. Marchetti	3
	Vibrational Spectroscopy Laboratory	CHEM-02/A	A. Vergara	3

Table A.2.2: Laboratory Core Courses - Track 2

Teachings	Modules	SSD	Teachers	ECTS
Solid-state and in solution structural characterization	Solid State Structural Characterization	CHEM-03/A	F. Borbone	3
	In solution characterization	CHEM-01/A	A. Amoresano	3
Biosynthesis and structural characterization of proteins	Production and purification of recombinant proteins	BIOS-07/A	A. Di Somma	3
	Protein Structure Laboratory	CHEM-02/A	A. Merlino	3
Molecular spectroscopy methods	NMR Spectroscopy Laboratory	CHEM-05/A	R. Marchetti	3
	Vibrational Spectroscopy Laboratory	CHEM-02/A	A. Vergara	3

Table A.2.3: Core Laboratory Courses - Track 3

Teachings	Modules	SSD	Teachers	ECTS
Solid-state and in solution structural characterization	Solid State Structural Characterization	CHEM-03/A	F. Borbone	3
	In solution characterization	CHEM-01/A	A. Amoresano	3
Biosynthesis and structural characterization of proteins	Production and purification of recombinant proteins	BIOS-07/A	A. Di Somma	3
	Protein Structure Laboratory	CHEM-02/A	A. Merlino	3
Synthesis and characterization methodologies	Coordination Chemistry Laboratory	CHEM-03/A	L. Leone	3
	Stereocontrolled Organic Synthesis Laboratory	CHEM-05/A	A. Guaragna	3

Table A.2.4: Laboratory Core Courses - Track 4

Teachings	Modules	SSD	Teachers	ECTS
Proteomics and metabolomics	Proteomics	BIOS-07/A	F. Cozzolino	3
	Analytical methods in metabolomics	CHEM-01/A	A. Amoresano	3
Molecular spectroscopy methods	NMR Spectroscopy Laboratory	CHEM-05/A	R. Marchetti	3
	Vibrational Spectroscopy Laboratory	CHEM-02/A	A. Vergara	3
Synthesis and characterization methodologies	Coordination Chemistry Laboratory	CHEM-03/A	L. Leone	3
	Stereocontrolled Organic Synthesis Laboratory	CHEM-05/A	A. Guaragna	3

Table A.2.5: Core Laboratory Courses - Track 5

Teachings	Modules	SSD	Teachers	ECTS
Biosynthesis and structural characterization of proteins	Production and purification of recombinant proteins	BIOS-07/A	A. Di Somma	3
	Protein Structure Laboratory	CHEM-02/A	A. Merlino	3
Proteomics and metabolomics	Proteomics	BIOS-07/A	F. Cozzolino	3
	Analytical methods in metabolomics	CHEM-01/A	A. Amoresano	3
Synthesis and characterization methodologies	Coordination Chemistry Laboratory	CHEM-03/A	L. Leone	3
	Stereocontrolled Organic Synthesis Laboratory	CHEM-05/A	A. Guaragna	3

Related and supplementary training activities

In order to customize his/her educational path, the student must take 2 of the courses indicated in the following table A.3, dividing them between the first and second year, until the completion of the 12 credits reserved for related and supplementary courses.

Table A.3: Related/supplementary courses

Teachings	GSD	Teachers	Semester	ECTN
Molecular biology	BIOS-08/A	A. Duilio	II	6
Forensic Analytical Chemistry	CHEM-01/A	M. Trifuoggi	II	6
Environmental chemistry	CHEM-01/B	M. Trifuoggi	I	6
Physical chemistry of renewable energy	CHEM-02/A	M. Pavone	I	6
Non-equilibrium thermodynamics for chemical, biological and environmental systems	CHEM-02/A	L. Petraccone	II	6
Catalysis Chemistry and Technology	CHEM-03/A	V. Busico	II	6
Chemistry of Organometallic Compounds	CHEM-03/A	M.E. Cucciolito	II	6
Chemistry of materials: from catalyst design to materials	CHEM-04/A	C. De Rosa	II	6
Chemistry of natural organic substances	CHEM-05/A	M. Masi	II	6
Special methodologies in organic synthesis	CHEM-05/A	D. Montesarchio	I	6

Educational activities chosen by the student

Students can select courses of their choice from all the courses offered by the Federico II University. In order to customize their educational path, students can take courses in both the first and second year until the completion of the 12 credits reserved for these activities. Exams of independent choice must be indicated by submitting the study plan according to the procedures indicated on the website of the CdS, https://www.scienzechimiche.unina.it/lmsc, or in the student guides, available on the website of the Polytechnic School and Basic Sciences (http://www.scuolapsb.unina.it/).
The list of courses suggested by the degree course is shown in the following table A.4. For these courses it is not necessary to submit a request for a study plan.

Table A.4: Elective courses (*Course taught in English)

Title	SSD	Semester	Teacher	ECTN
Bionanotechnology	BIOS-07/A - CHEM-07/C	II	P. Cicatiello	6
Methodologies for the environment and cultural heritage	CHEM-01/B	II	S. Pizzimenti	6
Molecular Modeling and Data Science for Chemistry	CHEM-02/A	I	N. Rega	6
Structure and dynamics of biological macromolecules	CHEM-02/A	I	R. Troisi	6
Chemistry education	CHEM-03/A	II	O. Tarallo	6
Metalloenzymes: from diagnostics to sustainability*	CHEM-03/A	II	A. Lombardi	6
Industrial Chemistry Products and Processes	CHEM-04/A	I	R. Turco	6
Chemistry of organic dyes	CHEM-05/A	II	M. Della Greca	6
Glycocomics*	CHEM-05/A	I	C. De Castro	6
Advanced methodologies for the characterization of organic compounds	CHEM-05/A	I	V. Piccialli	6
Supramolecular chemistry*	CHEM-05/A	II	C. Riccardi	6

N.B. Students cannot select optional exams that have already been passed in other study courses.

TRAINING PATH
Curriculum Chemical Sciences
A.A. 2025/2026
NB: all courses are taught in English

TEACHINGS	ECTS	Teachers	ECTS/ module	SSD	Activities (*)
Advanced Organic Chemistry *(I semester)*	6	A. Iadonisi	6	CHEM-05/A	m
Advanced Inorganic Chemistry *(I semester)*	6	M. Chino	6	CHEM-03/A	m
Advanced Analytical Chemistry *(I semester)*	6	S. Materazzi	6	CHEM-01/A	m
Complements of Physical Chemistry *(I semester)*	6	A. Merlino	6	CHEM-02/A	m
Advanced Biochemistry *(I semester)*	6	A. Carpentieri	6	BIOS-07/A	m
Integrated Laboratories (Tables A.6.1-A.6.5) *(II semester)*	18		3	BIOS-07/A CHEM-01/A CHEM-02/A CHEM-05/A CHEM-03/A	m
Related/complementary courses (Tab. A.7)	12		6	BIOS-07/A CHEM-01/A CHEM-02/A CHEM-03/A CHEM-04/A CHEM-05/A	r/c
Optional educational activities (Table A.4)	12		6		o
English Language Workshop	4				m
Internship and orientation activities	6				m
Experimental activity for the preparation of the Master's Degree thesis	6+31				m
Master's Degree Exam	1				m
TOTAL	**120**				

Legend of activities: m= mandatory; r/c-related/complementary; o= optional

The course of study includes 5 paths consisting of 3 laboratory courses, to ensure that all students complete the compulsory training required by the LM-54 degree class. In order to customize his/her educational path, the student enrolled in the "Chemical Sciences" Curriculum must compulsorily select 1 path among those listed in tables A.6.1 to A.6.5, dividing the respective exams of his/her choice between the first and second year, until the completion of the 18 CFU reserved for them. It should be noted that these courses are integrated, i.e. they consist of two modules of 3 credits that must be followed together and correspond to a single exam.

Table A.6.1: Laboratory Core Courses – Track A

Teachings	Modules	SSD	Teachers	ECTS
Biocatalysis	Bioinorganic catalysis	CHEM-03/A	D. D'Alonzo	3
	Enzymology	BIOS-07/A	O.F. Restaino	3
Nanoparticle functionalization for sensing applications	Synthetic strategies for nanoparticle functionalization with target-responsive organic molecules	CHEM-05/A	D. Musumeci	3
	Detection and quantification of target analytes using nanosensors	CHEM-01/A	G. Pinto	3
Chemical methods for the environment	Analytical chemistry methodologies for the environment	CHEM-01/A	A. Illiano	3
	Methods and models for environmental applications	CHEM-02/A	R. Oliva	3

Table A.6.2: Laboratory Core Courses – Track B

Teachings	Modules	SSD	Teachers	ECTS
Integrated modeling approaches in molecular catalysis: from ab initio to data driven	First principle techniques for data driven approaches	CHEM-02/A	A. Petrone	3
	High throughput experimentation, feature generation and data science approaches	CHEM-03/A	C. Ehm	3
Chemical methods for the environment	Analytical chemistry methodologies for the environment	CHEM-01/A	A. Illiano	3
	Methods and models for environmental applications	CHEM-02/A	R. Oliva	3
Bioprocesses for production of organic bioactive compounds	Isolation and structural characterization of organic bioactive compounds	CHEM-05/A	L. Panzella	3
	Bioprocesses and biotrasformations	BIOS-07/A	O.F. Restaino	3

Table A.6.3: Laboratory Characterizing Courses – Track C

Teachings	Modules	SSD	Teachers	ECTS
Integrated modeling approaches in molecular catalysis: from ab initio to data driven	First principle techniques for data driven approaches	CHEM-02/A	A. Petrone	3
	High throughput experimentation, feature generation and data science approaches	CHEM-03/A	C. Ehm	3
Biocatalysis	Bioinorganic catalysis	CHEM-03/A	D. D'Alonzo	3
	Enzymology	BIOS-07/A	O.F. Restaino	3
Nanoparticle functionalization for sensing applications	Synthetic strategies for nanoparticle functionalization with target-responsive organic molecules	CHEM-05/A	D. Musumeci	3
	Detection and quantification of target analytes using nanosensors	CHEM-01/A	G. Pinto	3

Table A.6.4: Laboratory Characterizing Courses – Track D

Teachings	Modules	SSD	Teachers	ECTS
Integrated modeling approaches in molecular catalysis: from ab initio to data driven	First principle techniques for data driven approaches	CHEM-02/A	A. Petrone	3
	High throughput experimentation, feature generation and data science approaches	CHEM-03/A	C. Ehm	3
Nanoparticle functionalization for sensing applications	Synthetic strategies for nanoparticle functionalization with target-responsive organic molecules	CHEM-05/A	D. Musumeci	3
	Detection and quantification of target analytes using nanosensors	CHEM-01/A	G. Pinto	3
Bioprocesses for production of organic bioactive compounds	Isolation and structural characterization of organic bioactive compounds	CHEM-05/A	L. Panzella	3
	Bioprocesses and biotrasformations	BIOS-07/A	O.F. Restaino	3

Table A.6.5: Laboratory Characterizing Courses – Track E

Teachings	Modules	SSD	Teachers	ECTS
Biocatalysis	Bioinorganic catalysis	CHEM-03/A	D. D'Alonzo	3
	Enzymology	BIOS-07/A	O.F. Restaino	3
Chemical methods for the environment	Analytical chemistry methodologies for the environment	CHEM-01/A	A. Illiano	3
	Methods and models for environmental applications	CHEM-02/A	R. Oliva	3
Bioprocesses for production of organic bioactive compounds	Isolation and structural characterization of organic bioactive compounds	CHEM-05/A	L. Panzella	3
	Bioprocesses and biotrasformations	BIOS-07/A	O.F. Restaino	3

Related and supplementary training activities

In order to customize his/her educational path, the student must take 2 of the courses indicated in the following table A.7, dividing them between the first and second year, until the completion of the 12 credits reserved for related and supplementary courses.

Table A.7: Related/supplementary courses

Teachings	SSD	Semester	Teacher	CFU
Chemistry of cultural heritage	CHEM-01/B	I	L. Birolo	6
Modelling of the photoinduced processes for earth and space	CHEM-02/A	I	A. Petrone	6
Soft matter and nanosystems	CHEM-02/A	II	I. Russo Krauss	6
Inorganic hybrid nanomaterials	CHEM-03/A	II	F. Nastri	6
Structural crystallography	CHEM-03/A	II	R. Centore	6
Chemistry of materials: from crystal structure to nanostructures	CHEM-04/A	II	C. De Rosa	6
Organic chemistry for renewable energies	CHEM-05/A	I	P. Manini	6

Educational activities chosen by the student

Students can select courses of their choice from all the courses offered by the Federico II University. In order to customize their educational path, students can take courses in both the first and second year until the completion of the 12 credits reserved for these activities. Exams of independent choice must be indicated by submitting the study plan according to the procedures indicated on the website of the CdS, https://www.scienzechimiche.unina.it/lmsc, or in the student guides, available on the website of the Polytechnic School and Basic Sciences (http://www.scuolapsb.unina.it/).
The list of courses suggested by the degree course is shown in the following table A.4. For these courses it is not necessary to submit a request for a study plan.

Table A.4: Elective courses (*Course taught in Italian)

Title	SSD	Semester	Teacher	ECTS
Bionanotechnology*	BIOS-07/A - CHEM-07/C	II	P. Cicatiello	6
Methodologies for the environment and cultural heritage*	CHEM-01/B	II	S. Pizzimenti	6
Molecular Modeling and Data Science for Chemistry*	CHEM-02/A	I	N. Rega	6
Structure and dynamics of biological macromolecules*	CHEM-02/A	I	R. Troisi	6
Chemistry Education*	CHEM-03/A	II	O. Tarallo	6
Metalloenzymes: from diagnosis to sustainability	CHEM-03/A	II	A. Lombardi	6
Industrial Chemistry Products and Processes*	CHEM-04/A	I	R. Turco	6
Chemistry of organic dyes*	CHEM-05/A	II	M. Della Greca	6
Glycomics	CHEM-05/A	I	C. De Castro	6
Advanced methodologies for the characterization of organic compounds*	CHEM-05/A	I	V. Piccialli	6
Supramolecular Chemistry	CHEM-05/A	II	C. Riccardi	6

N.B. Students cannot take optional exams that have already been passed in other study courses.

TRAINING ACTIVITY SHEETS

Curriculum "Scienze Chimiche"

Teaching: **ADVANCED ANALYTICAL CHEMISTRY**	**Language of delivery:** Italian
SSD: CHEM-01/A - Analytical Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: "The interest is aimed at scientific and didactic-training activities in the field of the development of theories, methodologies and instrumental techniques for the compositional-qualitative and quantitative and functional determination of chemical systems, both natural and synthetic in the various fields of chemistry. Theoretical models and chemometric tools for the evaluation of the quality and significance of chemical information are also developed and applied. All processes related to the pre-analytical stages are also studied - such as sampling, separation, enrichment and modification of the matrix and experimental and modeling processes for qualitative/quantitative/functional characterizations."	
Learning objectives: The course aims to develop the knowledge of instrumental analysis techniques (electrochemical, spectroscopic, chromatographic, radiochemical analysis methods, elemental analysis) and to introduce the statistical tools of chemometrics useful for the interpretation of analytical data.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **COMPLEMENTS OF PHYSICAL CHEMISTRY**	**Language of delivery:** Italian
SSD: CHEM-02/A - Physical Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: the proposed course is fully consistent with the CHEM-02/A declaration in the points: - "fundamental phenomena underlying chemical processes" - "study and development of theoretical, computational and experimental models and methodologies, with applications to production and technologies, for the interpretation and prediction of the behavior of complex systems, as well as the preparation of materials, including molecular ones, in the fields in which chemical sciences operate, and in those in which molecular	

interpretation is required. In particular, the skills concern the atomic, molecular, nanosystems, liquid and solid state fields"
- "thermodynamic, kinetic and catalytic reaction models and their understanding in terms of molecular properties and statistical mechanics"

Learning objectives:
To introduce the student to the theory and application of chemical-physical methods and models for the treatment of chemical systems ranging from diatomic to polyatomic molecules, from gaseous phases to condensed phases. In particular, the following topics will be addressed:
- Application of modern quantum theories (steady-state and time-dependent) to the treatment of polyelectronic systems from the gas phase to the crystalline phase.
- Models and methodologies for electron and vibrational spectroscopy of polyatomic molecules.
- Statistical thermodynamics applied to chemical kinetics and thermodynamic properties of condensed phases.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **SUPERIOR INORGANIC CHEMISTRY**	**Language of delivery:** Italian
SSD: CHEM-03/A – General and Inorganic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The proposed course is fully consistent with the declaration of the SSD CHEM-03/A in the following contents:
"The study of the reactivity, structural, spectroscopic, electrochemical and functional characterization of compounds of the main groups, transition series, lanthanides and actinoids, as well as coordination compounds and inorganic, bio-inorganic, supramolecular and nanostructured materials."

Learning objectives:
The course aims to deepen the aspects of the coordination bond, correlating the different models proposed. In particular, the course aims to provide advanced tools and knowledge so that the student can be able to:

- understand the electronic structure of transition metals and their coordination compounds;
- discuss the main chemical-physical and spectroscopic properties of complexes and their reactivity.

On the basis of the knowledge provided and the constant stimulus to critical discussion during the course, the student, independently, will be able to: a) construct orbitals of suitable symmetry (SALC) and molecular orbitals (MO); b) interpret the magnetic properties and electron spectra of

coordination compounds, based on their electronic structures; c) interpret vibrational spectra; d) solve problems concerning the structure, properties and reactivity relationships of coordination compounds.
In order to demonstrate how the fundamental concepts of inorganic chemistry can be applied to coordination compounds in different contexts, the properties of complexes with macromolecular ligands will be analyzed. In particular, metalloproteins will be described as elaborate inorganic complexes, their coordination chemistry and the relationships between structure and function of the metal site.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **ADVANCED ORGANIC CHEMISTRY**	**Language of delivery:** Italian
SSD: CHEM-05/A - Organic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The proposed course is fully consistent with the CHEM-05/A declaration in the following points: - "The following are studied: the development of efficient, sustainable and environmentally friendly synthesis methodologies also based on (stereo)selective and catalytic approaches, including organo-bio- and enzyme-catalytic ones, the elucidation of the mechanisms through which organic compounds are formed and transformed in the laboratory [...], the structural characterization of the organic substances under study and the structure-reactivity relationships."

Learning objectives:
The course aims to elaborate the knowledge acquired in the basic courses of Organic Chemistry towards a more comprehensive understanding of both the structure-reactivity correlation of organic molecules and the mechanisms of organic reactions. In the context of this introduction, part of the course aims to offer an overview of the most significant transformations used in the synthetic processing of bioactive molecules, with a critical analysis of the problems related to the selectivity of processes, their experimental design, and their impact in terms of sustainability.
Finally, the course aims to provide conceptual tools on spectroscopic methodologies useful for examining the course of the organic reactions examined.
At the end of the course the student should be able to: a) interpret the reactivity of organic molecules on the basis of their structure; b) predict the stereoselective regio-, chemo-, and course of organic reactions on the basis of the reaction mechanism; c) design synthetic pathways practicable in the selective processing of organic molecules with multiple functional groups; d) predict changes in the spectroscopic characteristics of molecules subjected to a synthetic modification; e) to present the concepts acquired clearly through the use of an adequate technical-scientific language.

Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **ADVANCED BIOCHEMISTRY**	**Language of delivery:** Italian	
SSD: BIOS-07/A Biochemistry		**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing	
Procedure In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the BIOS-07/A declaration as Biochemistry studies all biological processes at the molecular level, the structure, properties, intracellular localizations and functions of carbohydrate and lipid biomolecules, protein peptides and macromolecules, nucleic acids and supramolecular complexes; the molecular and regulatory mechanisms of biotransformations; bioenergetics, enzymes, metabolic pathways and their regulation, molecular and enzymatic mechanisms of gene conservation, expression and regulation; post-translational modifications and intra- and intercellular communications at the molecular level.		
Learning objectives: The course aims to provide and integrate the basic molecular knowledge of biochemistry necessary to understand the structural organization and structure-function relationships of proteins and nucleic acids, with particular reference to the main functional classes of proteins. Hints will be given on the processes related to protein expression (from genes to proteins), and we will focus on *protein* folding *in vitro* and *in vivo*, proteasomal *misfolding* and degradation, post-translational modifications, structure-function ratio in some classes of proteins (e.g. hemoglobin, immunoglobulins, proteases).		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		
Types of exams and other tests: Oral exam		

Teaching: **PROTEOMICS AND METABOLOMICS** BIOS-07/A Module: Proteomics Module CHEM-01/A: Analytical methods in metabolomics	**Language of delivery:** Italian

SSD: BIOS-07/A - Biochemistry CHEM01/A - Analytical Chemistry	**CFU:** 3+3
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The contents are consistent with the SSD sector declaration BIOS-07/A. Biochemical methodologies are aimed at the identification and structural and functional characterization of biomolecules, molecular biophysics, structural and computational biology, systems biology, bioinformatics, recombinant and omics molecular technologies (e.g. genomics, transcriptomics, proteomics, metabolomics) for the study of macromolecules and biological processes. The contents are in accordance with the provisions of the SSD CHEM-01/A sector declaration, concerning the "development of instrumental methodologies and techniques for the qualitative and quantitative compositional determination of chemical systems. Study of all processes and methodologies related to the preanalytical and interference stages of the matrix; advanced separation techniques, integrated analytical systems, spectroscopic and spectrometric techniques and characterization methods for the natural and productive environment and for safety".	
Learning objectives: The student will be introduced to the main application workflows in the field of proteomics and metabolomics, acquiring skills on differential methods for the extraction of proteins and metabolites from complex biological matrices, their identification and quantification by means of mass spectrometry methodologies integrated with bioinformatics methods. At the end of the course the student will have acquired an innovative vision of biological processes, typical of all "-omics" approaches and skills useful for interpreting the "perturbation" effects of a biological system at the molecular level.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **STRUCTURAL CHARACTERIZATION AT SOLID-STATE AND IN SOLUTION** CHEM-03/A Module: Solid State Structural Characterization CHEM-01/A Module: Solution Characterization	**Language of delivery:** Italian
SSD: CHEM-03/A - General and Inorganic Chemistry CHEM-01/A – Analytical Chemistry	**CFU:** 3+3
Course year: I or II	**Type of Training Activity:** Characterizing

Procedure:
Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The proposed course is fully consistent with the declaration CHEM-03/A and with the declaration CHEM-01/A in the points:
"Fundamental topics are the structural characterization of compounds of the main groups, transition series, as well as coordination compounds and inorganic, bio-inorganic, supramolecular and nanostructured materials. In addition, through experimental and theoretical-computational methods, structure-property relationships are studied and modeled." (CHEM-03/A)
"Development of methodologies and instrumental techniques for the qualitative and quantitative compositional determination of chemical systems. Study of all processes and methodologies related to the preanalytical and interference stages of the matrix; advanced separation techniques, integrated analytical systems, spectroscopic and spectrometric techniques and characterization methods for the natural and productive environment and for safety". (CHEM-01/A)

Learning objectives:
The student will acquire the theoretical and experimental skills necessary for the characterization of compounds both in solid state and in solution. Through practical exercises, the student will learn the basic notions and skills related to the growth and screening of single crystals, to the collection of data with the X-ray diffractometer and to the processing of data using crystallographic programs for the resolution and refinement of the crystal structure. The student will be able to analyze the molecular structure, the crystalline packaging and to highlight peculiar characteristics of some compounds, such as the geometry at the metal center in coordination compounds or the absolute configuration in chiral compounds. The same compounds or their precursors will be studied in solution matrices, allowing the learning of notions and skills for the development and optimization of analytical characterization methods, using spectroscopic techniques such as UV, IR, fluorescence and distribution and chiral chromatography techniques with different detectors. The analytical parameters necessary for quantitative analysis and data processing will also be defined.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **BIOSYNTHESIS AND STRUCTURAL CHARACTERIZATION OF PROTEINS** BIOS-07/A Module: Production and Purification of Recombinant Proteins CHEM-02/A Module: Protein Structure Laboratory	**Language of delivery:** Italian
SSD: BIOS-07/A – Biochemistry	**CFU:** 3+3

CHEM-02/A – Physical Chemistry	
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the declaration BIOS-07/A and with the declaration CHEM-02/A in the points: The BIOS-07/A sector includes biochemical methodologies for the identification and structural and functional characterization of biomolecules, and recombinant molecular technologies for the study of macromolecules and biological processes. In vitro simulations of biological systems, and development and application of theoretical models and chemometric tools for the evaluation of the quality and significance of chemical information (CHEM-02/A)	
Learning objectives: The student acquires both theoretical and experimental skills on DNA manipulation strategies and expression of recombinant proteins, their purification and structural and functional characterization. Acquires skills on the three-dimensional structure/function relationship of biological macromolecules thanks to the use of bioinformatics tools for the visualization and structural analysis of proteins, protein/ligand complexes and supramolecular complexes.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **MOLECULAR SPECTROSCOPY METHODS** Module CHEM-05/A. NMR Spectroscopy Laboratory CHEM-02/A Module Laboratory of Vibrational Spectroscopy	**Language of delivery:** Italian
SSD: CHEM-05/A - Organic Chemistry CHEM-02/A - Physical Chemistry	**CFU:** 3 + 3
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the CHEM-05/A declaration and with the CHEM-02/A declaration in the points:	

"The subject of study:... the structural characterization of the organic substances under study and the structure-reactivity relationships" (CHEM-05/A). "It deals with the isolation of organic substances... the determination of their structure, including stereochemistry, as well as the development of methods suitable for this purpose" (CHEM-05/A) "fundamental phenomena underlying chemical processes." (CHEM-02/A). "Study and development of theoretical, computational and experimental models and methodologies, with applications ... for the interpretation and prediction of the behavior of complex systems" (CHEM-02/A). spectroscopy... allows the characterization and interpretation of the properties of complex systems and their temporal evolution" (CHEM-02/A).
Learning objectives: The course aims to provide students with the theoretical and practical bases of NMR spectroscopy (one- and two-dimensional) and vibrational spectroscopies (FTIR and Raman), to be applied to the structural and conformational analysis of small and medium-sized molecules. For each proposed topic, the theoretical basis on the principle of operation will be provided and numerous applications to molecules of organic and inorganic interest will be presented and discussed. At the end of the course the student must be able to communicate clearly and with an adequate language his/her knowledge on the theoretical and experimental aspects of the molecular spectroscopies introduced. In particular, it must be able to interpret one- and two-dimensional NMR spectra and to predict the bands active at Raman and FTIR.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral test.

Teaching: **SYNTHESIS AND CHARACTERIZATION METHODOLOGIES** Module CHEM-03/A: Laboratory of Coordination Chemistry Form CHEM-05/A. Stereocontrolled Organic Synthesis Laboratory	**Language of delivery:** Italian
SSD: CHEM-03/A – General and Inorganic Chemistry CHEM-05/A - Organic Chemistry	**CFU:** 3 + 3
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the declaration CHEM-03/A and with the declaration CHEM-05/A in the points:	

"design and development of synthesis methodologies, the study of reactivity, structural, spectroscopic, electrochemical and functional characterization of compounds of the main groups, transition series, lanthanides and actinoids, as well as coordination compounds and inorganic, bio-inorganic, supramolecular and nanostructured materials" (CHEM-03/A).
"development of efficient, sustainable and environmentally friendly synthesis methodologies also based on (stereo)selective and catalytic approaches, including organobio- and enzyme-catalytic ones, the elucidation of the mechanisms through which organic compounds are formed" (CHEM-05/A).

Learning objectives:
The educational objective of the integrated course is to provide knowledge and skills for the synthesis and characterization of organic molecules and transition metal complexes. The course will allow students to approach chemical problems with an interdisciplinary vision, thanks to the application of concepts acquired in the fields of organic and inorganic chemistry. Through laboratory experiences, the course aims to develop skills, application skills and critical skills in the treatment of experimental results and in the definition of the relationships between chemical structure, spectroscopic properties and reactivity. In this regard, exercises will be carried out in which the synthesized organic molecules will be used as ligands for the synthesis of coordination compounds, and the synthesized complexes will be used as catalysts in stereoselective organic synthesis.
The laboratory aims to provide knowledge related to the main techniques of synthesis, purification and characterization of organic molecules, with particular regard to the basic principles of stereochemistry and those to deal with stereoselective synthesis. In addition, the main methodologies for the synthesis of coordination compounds and the most common spectroscopic techniques for their characterization (IR, UV-visible, Circular Dichroism spectroscopy) will be introduced.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **PHYSICAL CHEMISTRY OF RENEWABLE ENERGY**	**Language of delivery:** Italian
SSD: CHEM-02/A – Physical Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The proposed course is fully consistent with the CHEM-02/A declaration in the points: study and development of theoretical, computational and experimental models and methodologies, with applications to production and technologies, for the interpretation and prediction of the behavior of complex systems, as well as the preparation of materials, including molecular ones, in the fields in which chemical sciences operate, and in those in which molecular interpretation is required. In

particular, in areas such as materials and energy science, including the study of natural and anthropogenic systems, with models for sustainability.
Learning objectives: The aim of the course is to provide knowledge of the chemical-physical principles underlying the operation of important technologies to obtain energy from renewable and sustainable sources, with particular attention to the thermodynamic, kinetic and quantum-mechanical aspects underlying energy conversion and storage: from solar energy to batteries, from molecular hydrogen to nuclear energy. The student also learns what specific characteristics materials and devices must possess in order to optimize the efficiency of these very current technologies in the context of the transition to energy sustainability.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **FORENSIC ANALYTICAL CHEMISTRY**	**Language of delivery:** Italian	
SSD: CHEM-01/A – Analytical Chemistry		**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the CHEM-01/A declaration in the points: "Development of theories, methodologies and instrumental techniques for the qualitative and quantitative compositional determination of chemical systems, both natural and synthetic, in the different fields of chemistry. Study and development of methods, devices and instrumentation for sensors and biosensors, environmental protection, medical diagnostics, separative, spectroscopic and spectrometric analytical techniques, integrated analytical systems, speciation and metrology. Development and application of theoretical models and chemometric tools for the evaluation of quality and significance of chemical information. Development and application of diagnostic and material protocols, and non-destructive and microdestructive analyses".		
Learning objectives: The course of Forensic Analytical Chemistry aims to impart to students the knowledge necessary for the understanding of the principles and techniques used in forensic chemical sciences and analysis. The student will be guided through the phases of sampling, chemical analysis, up to data processing and interpretation so that he or she acquires mastery of all the processes involved in forensic chemical analysis.		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		
Types of exams and other tests: Oral exam		

Teaching: **ENVIRONMENTAL CHEMISTRY**	**Language of delivery:** Italian
SSD: CHEM-01/B – Chemistry of the Environment and Cultural Heritage	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the CHEM-01/B declaration in the points: "Development of theories, methodologies and instrumental techniques for the qualitative and quantitative compositional determination of chemical systems, both natural and synthetic, in the different fields of chemistry. Study and development of methods, devices and instrumentation for sensors and biosensors, environmental protection, medical diagnostics, separative, spectroscopic and spectrometric analytical techniques, integrated analytical systems, speciation and metrology. Development and application of theoretical models and chemometric tools for the evaluation of quality and significance of chemical information. Development and application of diagnostic and material protocols, and non-destructive and microdestructive analyses".	
Learning objectives: The course of Environmental Chemistry aims to impart to students the knowledge necessary for the understanding of the principles and techniques used in environmental chemical sciences and analyses. The student will be guided through the phases of sampling, chemical analysis, up to the processing and interpretation of data so that he or she acquires mastery of all the processes involved in environmental chemical analysis.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam.	

Teaching: **CHEMISTRY AND TECHNOLOGY of CATALYSIS**	**Language of delivery:** Italian
SSD: CHEM-03/A – General and Inorganic Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: Design and development of synthesis methodologies, reactivity study, structural, spectroscopic, electrochemical and functional characterization of principal group compounds, transition series, lanthanides and actinoids, as well as coordination compounds and inorganic, bio-inorganic, supramolecular and nanostructured materials. In addition, through experimental and theoretical-	

computational methods, the reaction mechanisms, both at the molecular and macroscopic level, the catalytic processes and the structure-property relationships are studied and modeled. The study, the general areas of interest and the use of knowledge, related to the chemical properties of elements and their compounds, consider levels ranging from basic research to applications in all sectors of chemistry, including energy, with attention to issues related to sustainability and circularity.
Learning objectives: In a first part of a general nature, the course aims to provide students with the principles underlying coordination catalysis, both in the homogeneous phase and on surfaces, and then to deepen its applications and technological aspects in a second part of a monographic nature, taking as main examples the Fischer-Tropsch synthesis and the stereoselective polymerization of olefins. The new developments of statistical modeling using Machine Learning and Deep Learning algorithms applied to databases obtained by High Throughput Experimentation will be covered in the third and last part.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **CHEMISTRY OF METAL-ORGANIC COMPOUNDS**	**Language of delivery:** Italian
SSD: CHEM-03/A – General and Inorganic Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: This course presents contents consistent with the declatory of the SSD CHIM/03 as it is interested in the study of synthesis methodologies, reactivity, structural and spectroscopic characterization of compounds of the main groups, transition series, lanthanides and actinoids, as well as coordination compounds. In addition, reaction mechanisms, catalytic processes and structure-property relationships are studied.	
Learning objectives: The course aims to provide students with knowledge on metal-organic compounds with regard to synthesis, reactivity, applications and their impact. This knowledge will allow students to understand the relationships between properties and structure, which determine chemical behavior and possible applications.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **NON-EQUILIBRIUM THERMODYNAMICS FOR CHEMICAL, BIOLOGICAL AND ENVIRONMENTAL SYSTEMS**	**Language of delivery:** Italian
SSD: CHEM-02/A – Physical Chemistry	**CFU:**6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: **In presence**	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The scientific disciplinary sector is interested in the research and teaching-training of the fundamental phenomena underlying chemical processes. In particular, he deals with the study and development of theoretical, computational and experimental models and methodologies for the interpretation and prediction of the properties of complex systems and their temporal evolution.	
Learning objectives: The aim of the course is to introduce the principles of thermodynamics of non-equilibrium systems, with particular attention to its applications in the chemical, biological and environmental fields. The analysis of these systems will be addressed by initially considering the conditions necessary for chemical processes to give rise to phenomena of spatial and temporal self-organization. The approach will then be generalized to show how the techniques developed allow to rationalize many non-intuitive behaviors of complex systems consisting of a large number of elements that interact with each other through nonlinear relationships. It will be shown, through various examples, how this approach allows to frame in a single conceptual framework apparently different phenomena such as the origin and evolution of the biosphere, the evolution of the Earth's climate, the variation of an insect population as well as the birth of ordered structures in the early Universe.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **MOLECULAR BIOLOGY**	**Language of delivery:** Italian
SSD: BIOS-08/A - Molecular Biology	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure In presence	

Contents extracted from the SSD declaration consistent with the educational objectives of the course: The sector is interested in scientific and teaching-training activities in the field of biological functions which, at the molecular level, concern the study of the molecular mechanisms of biological processes and the structure and regulation of biological macromolecules, in viruses, prokaryotes and eukaryotes, involved in cellular functions such as DNA replication, repair and recombination, chromatin structure and functions and nuclear organization, transcription and maturation of RNAs, coding and non-encoding RNAs, translation, maturation and degradation of proteins, and molecular signaling mechanisms.
Learning objectives: The course aims to provide a description of the structure and chemistry of nucleic acids and of the molecular events that underlie the processes of conservation, duplication and expression of gene information. The course is also aimed at providing a general set of knowledge on the regulation of gene expression in eukaryotic and prokaryotic organisms with particular regard to promoter structure, DNA-protein interaction and cell topogenesis.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **CHEMISTRY OF NATURAL ORGANIC SUBSTANCES**		**Language of delivery:** Italian
SSD: CHEM-05/A - Organic Chemistry		**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the CHEM-05/A declaration in the points: - "The scientific disciplinary sector is interested in ... of the study of carbon compounds, both of natural and synthetic origin" - "The following are being studied: ....the structural characterization of organic substances and the structure-reactivity relationships" - "It deals with the isolation of organic substances of animal, plant and marine origin, also with biological activity, the determination of their structure including stereochemistry as well as the development of methods suitable for this purpose and their synthesis."		
Learning objectives: The course aims to acquire knowledge on the most important classes of natural organic substances and in particular on their structure, biosynthesis and structure-reactivity relationships. In addition, the course aims to provide knowledge: a) on the techniques used for their isolation and their chemical and biological characterization; b) on the hemisynthesis of derivatives and/or analogues for the modulation of their activity and specificity aimed at potential practical application in the		

agri-food industry, in the cosmetic and pharmaceutical industry and in the protection of the environment and cultural heritage. At the end of the course the student must be able to know the structure of the main classes of natural compounds and which are the biosynthetic pathways from which they are generated. The student must also be able to apply the methodological tools learned for the purification and identification of natural organic compounds.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam.

Teaching: **SPECIAL METHODOLOGIES IN ORGANIC SYNTHESIS**	**Language of delivery:** Italian	
SSD: CHEM-05/A – Organic Chemistry		**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The course is fully consistent with the CHEM-05/A declaration, in particular with regard to, as "object of study: the development of efficient, sustainable and environmentally friendly synthesis methodologies also based on (stereo)selective and catalytic approaches, including organo-, bio- and enzyme-catalytic ones, the elucidation of the mechanisms through which organic compounds are formed and transformed both in the laboratory and in natural and environmental systems, their supramolecular interactions, ... and structure-reactivity relationships. … He also deals with the design, chemical synthesis of biologically active compounds, organic materials, supramolecular systems, polymers and bio-polymers, the study of new catalysts with reference also to their development in application areas. The group also looks at the effect of organic molecules on the environment, and the circularity and sustainability of processes involving organic compounds."		
Learning objectives: The aim of the course is to provide the student with knowledge in terms of structural characteristics, structure-activity relationships and synthesis methods of the main classes of biopolymers (peptides, oligonucleotides, oligosaccharides) and their synthetic analogues. In addition, the student must become familiar with combinatorial synthesis and rational targeted synthesis approaches applied to drug *discovery processes*, as well as with special methods in organic synthesis (e.g.: solid-phase synthesis, use of *scavengers*, microwaves, ionic liquids, multi-component reactions, bio-conjugation and click-chemistry reactions).”). The student must be able to: i) design a synthesis of complex multifunctional molecules (biopolymers, small organic molecules, etc.) by developing appropriate retrosynthetic schemes in a perspective of optimal feasibility, efficacy and sustainability; ii) discuss the choice of appropriate methods of protection of functional groups or their activators; iii) evaluate the best synthetic strategies and reaction conditions for obtaining synthetic targets in relation to possible practical applications.		

Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **CHEMISTRY OF MATERIALS: FROM CATALYST DESIGN TO MATERIALS**	**Language of Instruction:** Italian
SSD: CHEM-04/A – Industrial Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Teaching method: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The scientific disciplinary sector is interested in the scientific and didactic-training activity in the field of science and technology [..] of chemical products, materials and processes [..], through the definition of the principles and the study of the thermodynamic, kinetic, catalytic and technological aspects related to them [..]. It deals with the sustainable development, optimization and management of industrial processes with particular attention to the related problems of technologies for the reduction of the impact on the environment and [..]the design of eco-friendly materials [..]. The scientific disciplinary sector also deals with the synthesis, reactivity and modification of polymeric, functional, hybrid and composite materials, with particular attention to the problems of circularity and enhancement of resources and is also interested in the chemical and technological properties of polymeric materials, their characterization and structure-property relationships.	
Learning objectives: The course aims to provide the fundamental notions of solid state materials chemistry, from the description of molecular and crystalline structures to the analysis of final physical properties. The course aims to provide the concepts that allow to design a material with the desired physical and mechanical properties starting from the design of the catalyst used in the synthetic strategy used for the preparation of the material. The aim is to study the relationships between catalyst structure, molecular and crystalline structure of the material produced and final properties, through the modeling of the mechanisms of reactions promoted by catalysts (including stereoselective) and the characterization of materials by scattering, diffraction and microscopy techniques and analysis of mechanical properties. The structures and properties of metallic, ceramic and polymeric materials are described with particular emphasis on new polymers with a molecular structure designed ab-initio to allow chemical recycling in the context of the perfect circularity of the polymer materials economy.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam.	

Curriculum "Chemical Sciences"

Teaching: **ADVANCED ANALYTICAL CHEMISTRY**	**Language of delivery:** English
SSD: CHEM-01/A - Analytical Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: "The interest is aimed at scientific and didactic-training activities in the field of the development of theories, methodologies and instrumental techniques for the compositional-qualitative and quantitative and functional determination of chemical systems, both natural and synthetic in the various fields of chemistry. Theoretical models and chemometric tools for the evaluation of the quality and significance of chemical information are also developed and applied. All processes related to the pre-analytical stages are also studied - such as sampling, separation, enrichment and modification of the matrix and experimental and modeling processes for qualitative/quantitative/functional characterizations."	
Learning objectives: The course aims to develop the knowledge of instrumental analysis techniques (electrochemical, spectroscopic, chromatographic, radiochemical analysis methods, elemental analysis) and to introduce the statistical tools of chemometrics useful for the interpretation of analytical data.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **COMPLEMENTS OF PHYSICAL CHEMISTRY**	**Language of delivery:** English
SSD: CHEM-02/A Physical Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: the proposed course is fully consistent with the CHEM-02/A declaration in the points: - "fundamental phenomena underlying chemical processes" - "study and development of theoretical, computational and experimental models and methodologies, with applications to production and technologies, for the interpretation and prediction of the behavior of complex systems, as well as the preparation of materials, including molecular ones, in the fields in which chemical sciences operate, and in those in which molecular	

interpretation is required. In particular, the skills concern the atomic, molecular, nanosystems, liquid and solid state fields"
- "thermodynamic, kinetic and catalytic reaction models and their understanding in terms of molecular properties and statistical mechanics"

Learning objectives:
To introduce the student to the theory and application of chemical-physical methods and models for the treatment of chemical systems ranging from diatomic to polyatomic molecules, from gaseous phases to condensed phases. In particular, the following topics will be addressed:
- Application of modern quantum theories (steady-state and time-dependent) to the treatment of polyelectronic systems from the gas phase to the crystalline phase.
- Models and methodologies for electron and vibrational spectroscopy of polyatomic molecules.
- Statistical thermodynamics applied to chemical kinetics and thermodynamic properties of condensed phases.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **ADVANCED INORGANIC CHEMISTRY**	**Language of delivery:** English
SSD: CHEM-03/A – General and Inorganic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The proposed course is fully consistent with the declaration of the SSD CHEM-03/A in the following contents:
"The study of the reactivity, structural, spectroscopic, electrochemical and functional characterization of compounds of the main groups, transition series, lanthanides and actinoids, as well as coordination compounds and inorganic, bio-inorganic, supramolecular and nanostructured materials."

Learning objectives:
The course aims to deepen the aspects of the coordination bond, correlating the different models proposed. In particular, the course aims to provide advanced tools and knowledge so that the student can be able to:

- understand the electronic structure of transition metals and their coordination compounds;
- discuss the main chemical-physical and spectroscopic properties of complexes and their reactivity.

On the basis of the knowledge provided and the constant stimulus to critical discussion during the course, the student, independently, will be able to: a) construct orbitals of suitable symmetry (SALC) and molecular orbitals (MO); b) interpret the magnetic properties and electron spectra of

coordination compounds, based on their electronic structures; c) interpret vibrational spectra; d) solve problems concerning the structure, properties and reactivity relationships of coordination compounds.
In order to demonstrate how the fundamental concepts of inorganic chemistry can be applied to coordination compounds in different contexts, the properties of complexes with macromolecular ligands will be analyzed. In particular, metalloproteins will be described as elaborate inorganic complexes, their coordination chemistry and the relationships between structure and function of the metal site.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **ADVANCED ORGANIC CHEMISTRY**	**Language of delivery:** English
SSD: CHEM-05/A Organic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The proposed course is fully consistent with the CHEM-05/A declaration in the following points: - "The following are studied: the development of efficient, sustainable and environmentally friendly synthesis methodologies also based on (stereo)selective and catalytic approaches, including organo-bio- and enzyme-catalytic ones, the elucidation of the mechanisms through which organic compounds are formed and transformed in the laboratory [...], the structural characterization of the organic substances under study and the structure-reactivity relationships."

Learning objectives:
The course aims to elaborate the knowledge acquired in the basic courses of Organic Chemistry towards a more comprehensive understanding of both the structure-reactivity correlation of organic molecules and the mechanisms of organic reactions. In the context of this introduction, part of the course aims to offer an overview of the most significant transformations used in the synthetic processing of bioactive molecules, with a critical analysis of the problems related to the selectivity of processes, their experimental design, and their impact in terms of sustainability.
Finally, the course aims to provide conceptual tools on spectroscopic methodologies useful for examining the course of the organic reactions examined.
At the end of the course the student should be able to: a) interpret the reactivity of organic molecules on the basis of their structure; b) predict the stereoselective regio-, chemo-, and course of organic reactions on the basis of the reaction mechanism; c) design synthetic pathways practicable in the selective processing of organic molecules with multiple functional groups; d) predict changes in the spectroscopic characteristics of molecules subjected to a synthetic modification; e) to present the concepts acquired clearly through the use of an adequate technical-scientific language.

Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **ADVANCED BIOCHEMISTRY**	**Language of delivery:** English	
SSD: BIOS-07/A Biochemistry		**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Characterizing	
Procedure In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the BIOS-07/A declaration as Biochemistry studies all biological processes at the molecular level, the structure, properties, intracellular localizations and functions of carbohydrate and lipid biomolecules, protein peptides and macromolecules, nucleic acids and supramolecular complexes; the molecular and regulatory mechanisms of biotransformations; bioenergetics, enzymes, metabolic pathways and their regulation, molecular and enzymatic mechanisms of gene conservation, expression and regulation; post-translational modifications and intra- and intercellular communications at the molecular level.		
Learning objectives: The course aims to provide and integrate the basic molecular knowledge of biochemistry necessary to understand the structural organization and structure-function relationships of proteins and nucleic acids, with particular reference to the main functional classes of proteins. Hints will be given on the processes related to protein expression (from genes to proteins), and we will focus on *protein* folding *in vitro* and *in vivo*, proteasomal *misfolding* and degradation, post-translational modifications, structure-function ratio in some classes of proteins (e.g. hemoglobin, immunoglobulins, proteases).		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		
Types of exams and other tests: Oral exam		

Teaching: **BIOCATALYSIS** Modulo CHEM-03/A: Bioinorganic catalysis Modulo BIOS-07/A: Enzymology	**Language of delivery:** English
SSD:	**CFU:**

CHEM-03/A: General and Inorganic Chemistry BIOS-07/A: Biochemistry	3+3 CFU
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: the proposed course is consistent with the declarations of the scientific-disciplinary sectors CHEM-03/A and BIOS-07/A in the points: "design and development of synthesis methodologies, reactivity study, structural, spectroscopic, electrochemical and functional characterization of coordination compounds and bio-inorganic materials". "Reaction mechanisms, both at molecular and macroscopic level, catalytic processes and structure-property relationships". (CHEM-03/A) "Biochemical methodologies for the identification and structural and functional characterization of enzymes". (BIOS-07/A)	
Learning objectives: The course aims to provide students with in-depth knowledge of the fundamental principles of enzyme-mediated catalysis, with particular attention to metalloenzymes, highlighting the correlation between structure and function in natural biocatalysts and artificial biomimetic systems. Molecular and kinetic aspects of enzymatic catalysis will be illustrated and at the same time the main biochemical techniques necessary for the isolation and functional characterization of enzymes. The key concepts of coordination chemistry will be applied to biomolecular systems, essential to understand the role of metal ions in biocatalysis. Laboratory activities will focus on the synthesis, purification, immobilization, structural analysis and evaluation of the catalytic properties of natural and synthetic biocatalysts.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam.	

Teaching: **NANOPARTICLE FUNCTIONALIZATION FOR SENSING APPLICATIONS** Modulo CHEM-05/A: Synthetic strategies for nanoparticle funcionalization with target-responsive organic molecules Modulo CHEM-01/A: Detection and quantification of target analytes using nanosensors	**Language of delivery:** English
SSD: CHEM-05/A – Organic Chemistry CHEM-01/A – Analytical Chemistry	**CFU:** 3+3
Course year: I or II	**Type of Training Activity:** Characterizing

Procedure:
Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
the proposed course is consistent with the declarations of the scientific-disciplinary sectors CHEM-05/A and CHEM 01/A in the points:
"The following are being studied: the development of efficient, sustainable and environmentally friendly synthesis methodologies also based on (stereo)selective and catalytic approaches, the elucidation of the mechanisms through which organic compounds are formed and transformed ... in the laboratory..., their supramolecular interactions, the structural characterization of the organic substances under study and the structure-reactivity relationships. … (The SSD) is also involved in the design, chemical synthesis of ... supramolecular systems with reference also to their development in application areas." (CHEM-05/A)
"Analytical Chemistry develops theories, methodologies, techniques and instrumentation to determine the qualitative and quantitative composition and structure of natural and artificial chemical systems with different states of aggregation and variable complexity, also in the field of bioanalytics and commodity. All the processes related to the pre-analytical stages (sampling, separation, enrichment, matrix modifications) as well as the development and use of tools for the objective evaluation of the quality of numerical information (e.g. chemometrics) are also studied in this area." (CHEM-01/A)

Learning objectives:
The course aims to provide students with theoretical preparation and practical skills on the main synthetic strategies for the functionalization of nanoparticles (e.g., magnetic or silica) with organic molecules suitable for the detection of various analytes (e.g., metal ions, organic pollutants, biological *targets*, etc.), for obtaining appropriate sensors useful in the environmental field. agri-food, diagnostic. Students will also acquire theoretical and experimental knowledge on the most widely used techniques for the purification and characterization of functionalized nanoparticles and on the development of an analytical method aimed at the detection and quantification of analytes in solution and in complex mixtures.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **BIOPROCESSES FOR PRODUCTION OF ORGANIC BIOACTIVE COMPOUNDS** Modulo CHEM-05/A: Isolation and structural characterization of organic bioactive compounds Modulo BIOS-07/A: Bioprocesses and biotrasformations	**Language of delivery:** English
SSD: CHEM-05/A – Organic Chemistry	**CFU:** 3+3

BIOS-07/A - Biochemistry	
Course year: I or II	**Type of Educational Activity:** Characterizing
Procedure: Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: CHEM-05/A: Development of efficient, sustainable and environmentally friendly synthesis methodologies based on bio- and enzyme-catalytic approaches and isolation of organic substances of plant origin and determination of their structure. BIOS-07/A: Biochemistry of microorganisms and industrial biochemistry. Regulation of biotransformations and metabolic pathways. Biotechnological applications and the development of innovative processes	
Learning objectives: The course aims to provide students with knowledge regarding: 1) the main bioactive organic compounds recoverable from biomass of plant origin and the strategies commonly used for their valorization; 2) the main microbial growth processes in flask and fermenter; 3) bioprocesses of microbial production and biotransformation to obtain bioactive compounds with high added value also using biomass of plant origin as growth substrates; 4) the methodologies commonly used for the isolation and structural characterization of bioactive organic compounds in complex plant matrices.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **CHEMICAL METHODS FOR THE ENVIRONMENT** Modulo CHEM-02/A: Methods and models for environmental applications Modulo CHEM-01/A: Analytical chemistry methodologies for the environment	**Language of delivery:** English
SSD: CHEM-02/A- Physical Chemistry CHEM-01/A – Analytical Chemistry	**CFU:** 3+3
Course year: I or II	**Type of Educational Activity**: Characterizing
Procedure: Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: CHEM-02/A: "study and development of theoretical, computational and experimental models and methodologies, with applications to production and technologies, for the interpretation and prediction of the behavior of complex systems including the study of natural and anthropogenic systems, with models for sustainability and the circular economy".	

CHEM-01/A: "Development of instrumental methodologies and techniques for the qualitative and quantitative compositional determination of chemical systems. Study of all processes and methodologies related to the preanalytical and interference stages of the matrix; advanced separation techniques, integrated analytical systems, techniques and methods of characterization for the natural and productive environment and for safety".

Learning objectives:
The course aims to provide basic knowledge on the main chemical-physical and chemical-analytical methods for applications in the environmental field.
Through laboratory practice, the student will be able to acquire skills on the instrumentation for modern environmental analysis, including optical spectroscopy and micro-calorimetry methods and methods of qualitative and quantitative analysis of even complex environmental matrices. The proposed activities will involve the active participation of students from the planning of the experiments, to their implementation up to the interpretation of the experimental data.
In addition, the student will acquire skills on current environmental regulations and sampling strategies.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **INTEGRATED MODELING APPROACHES IN MOLECULAR CATALYSIS: FROM *AB INITIO* TO DATA DRIVEN** Modulo CHEM-02/A: First principle techniques for data driven approaches Modulo CHEM-03/A: High throughput experimentation, feature generation and data science approaches	**Language of delivery:** English
SSD: CHEM-02/A – Physical Chemistry CHEM-03/A – General and Inorganic Chemistry	**CFU:** 3 + 3
Course year: I or II	**Type of Educational Activity:** Characterizing

Procedure:
Lectures and laboratory to be carried out in presence. Compulsory attendance (70% minimum)

Contents extracted from the declarations of the SSDs consistent with the training objectives of the course:
The CHEM-02/A module is fully consistent with the sector declaration in the points: study and development of theoretical, computational and experimental models and methodologies for the description, interpretation and prediction of the behavior and properties of complex chemical systems. Thermodynamics, spectroscopy, computational modeling allow the characterization and interpretation of the properties of complex systems and their temporal evolution.
The CHEM-03/A module is fully consistent with the industry declaration in the following areas: design and development of synthesis methodologies, reactivity study, structural, spectroscopic,

and functional characterization of transition series group compounds, coordination compounds and supramolecular materials. Reaction mechanisms at the molecular level, catalytic processes and structure-property relationships are modelled.
Learning objectives: The course aims to provide a *hands-on* introduction to the predictive modeling of selective chemical processes important for a circular economy mediated by molecular organometallic catalysts, with an *ab initio* versus a *data-driven approach.* The exercises will concern representative catalytic reactions, exploring the ability to modulate performance and selectivity. Students will be able to generate the structure-properties of catalysts using experimental data, obtained with *High Throughput Experimentation* (*HTE) methods*, and computational data, obtained from quantum computing (DFT) methodologies. The aim is to illustrate the theoretical and applicative bases of each approach, evaluating the limitations and advantages of *ab initio* methodologies and statistical modeling approaches (machine learning, unsupervised learning, clustering, 'black-box' modeling) for the prediction of spectroscopic data and reaction profiles. At the end of the course, the student will be able to constructively evaluate and design integrated approaches to rapidly improve catalytic processes to meet the challenges of the 21st century, for example resource management and sustainability.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **CHEMISTRY OF CULTURAL HERITAGE**	**Language of delivery:** English
SSD: CHEM-01/B Chemistry of the Environment and Cultural Heritage	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The contents are consistent with the declaration of the sector that is interested in the development and application of diagnostic methods for the characterization of environmental matrices and of historical-artistic interest and sustainable interventions for the monitoring and speciation of pollutants, their characterization in the environment and in the historical-artistic heritage.	
Learning objectives: The course aims to provide the student with the basic knowledge of materials in archaeological finds and works of art, with particular attention to the characterization of the degradation and aging processes of the different classes of molecules.	
Prerequisites for entry: NONE	

Prerequisites for exit: NONE
Types of exams and other tests: Oral exam

Teaching: **MODELLING OF THE PHOTOINDUCED PROCESSES FOR EARTH AND SPACE**	**Language of delivery:** English	
SSD: CHEM-02/A – Physical Chemistry		**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The course is fully consistent with the CHEM-02/A declaration in the points: study and development of theoretical, computational and experimental models and methodologies for the description, interpretation and prediction of the behavior and properties of complex chemical systems. In particular, the skills concern the atomic, molecular, [...] synthetic and biological macromolecules, and areas such as materials science, biomedical sciences, energy and cultural and environmental heritage, including the study of natural and anthropogenic systems, with models for sustainability and the circular economy. Thermodynamics, spectroscopy, computational modeling allow the characterization and interpretation of the properties of complex systems and their temporal evolution.		
Learning objectives: The aim of the course is to provide students with the knowledge and modern methods for understanding photochemical and photoinduced processes in different matrices. The course also intends to present different theoretical-computational methodologies for the study of these phenomena, illustrating the theoretical and applicative bases of the chemical-physical principles of the molecular processes induced by electromagnetic radiation at the basis of important natural and technological phenomena in different conditions, with particular interest in extreme environments (i.e. low pressure, high temperature) for their environmental importance, energetics and astrochemistry. The student will also learn the principles of modeling to accurately describe the interaction of matter with electromagnetic radiation and its dynamic behavior. Particular attention is paid to the most modern spectroscopic techniques, resolved over time, able to study these processes at the molecular level and on ultrafast time scales. The course also includes computer laboratory exercises of molecular modeling for the treatment of photoinduced phenomena through *ab initio* methodologies and molecular and electronic dynamics. At the end of the course, the student will be able to evaluate and apply the techniques learned to model the phenomena underlying modern environmental, energy and astrochemical issues (i.e., degradation of pollutants in the atmosphere, functioning of solar cells, molecular basis of the origin of prebiotic molecules in space and on earth), choosing a case study agreed with the teacher.		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		

Types of exams and other tests: Oral exam.

Teaching: **ORGANIC CHEMISTRY FOR RENEWABLE ENERGIES**	**Language of delivery:** English
SSD: CHEM-05/A - Organic Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: Face-to-face lectures	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the CHEM-05/A declaration in the points: - "The scientific disciplinary sector is interested in ... of the study of carbon compounds, both of natural and synthetic origin" - "The following are being studied: ....the structural characterization of organic substances and the structure-reactivity relationships"	
Learning objectives: The aim of the course is to provide the student with knowledge on the main types of devices that exploit organic compounds for the sustainable production of energy from renewable sources. In particular, the course aims to provide knowledge on: 1) main synthetic methodologies for the preparation of organic compounds of interest; 2) the main techniques of structural characterization and chemical-physical properties; 3) the main process techniques of organic compounds for the manufacture of the devices in question	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **INORGANIC HYBRID NANOMATERIALS**	**Language of delivery:** English
SSD: CHEM-03/A - General and Inorganic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Related or complementary
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The educational objectives of the course are consistent with the following contents: "Fundamental topics are the design and development of synthesis methodologies, the study of reactivity, the structural, spectroscopic, electrochemical and functional characterization of compounds of the	

main groups, transition series, lanthanides and actinoids, as well as coordination compounds and inorganic materials, bio-inorganic, supramolecular and nanostructured"
Learning objectives: Nanomaterials and nanoparticles represent a rapidly growing field of research and a rapidly expanding field of technology for a variety of applications. This course aims to provide a description of hybrid inorganic nanomaterials, obtained from the combination of metal-based nanomaterials and metal oxides with biological molecules characterized by broad functionality and stability, such as proteins, enzymes, polysaccharides, nucleic acids and lipids, thus creating structures with controlled dimensions at the nanoscale. The resulting hybrid inorganic nanomaterials have different applications in chemistry, engineering, diagnostics and medicine. The course will provide the student with a general knowledge of nanotechnologies and its applications. In particular, different types of nanoparticles and inorganic nanomaterials will be described, describing their use as catalysts and sensors, with different applications.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **CHEMISTRY OF MATERIALS: FROM CRYSTAL STRUCTURE TO NANOSTRUCTURES**	**Language of Instruction:** English
SSD: CHEM-04/A- Industrial Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Teaching method: Face-to-face lectures	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The scientific disciplinary sector is interested in the scientific and didactic-training activity in the field of science and technology [..] of chemical products, materials and processes [..], through the definition of the principles and the study of the thermodynamic, kinetic, catalytic and technological aspects related to them [..]. It deals with the sustainable development, optimization and management of industrial processes with particular attention to the related problems of technologies for the reduction of the impact on the environment and [..]the design of eco-friendly materials [..]. The scientific disciplinary sector also deals with the synthesis, reactivity and modification of polymeric, functional, hybrid and composite materials, with particular attention to the problems of circularity and enhancement of resources and is also interested in the chemical and technological properties of polymeric materials, their characterization and structure-property relationships.	
Learning objectives: The course aims to provide the fundamental notions on the solid-state structure of materials, from crystalline structures, to mesofases, to nanostructures. The aim is to provide the concepts underlying the molecular approach in the study of the physical and mechanical properties of materials (metallic, ceramic and polymeric) that allows to interpret and correlate the properties of use of a material to	

its molecular and crystalline structure. The main methods for the production of nanostructures through the bottom-up and self-assembly approach and the possible applications of nanostructures in nanotechnologies, from microelectronics to medicine, are described. The course provides notions on advanced techniques of structural and morphological characterization of materials, such as X-ray and electron diffraction, low-angle scattering of X-rays and neutrons, calorimetry, and innovative microscopy techniques, such as optical microscopy, transmission and scanning electron microscopy and atomic force microscopy and methods for the characterization of the mechanical properties of materials.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam.

Teaching: **SOFT MATTER AND NANOSYSTEMS**		**Language of delivery:** English
SSD: CHEM-02/A- Physical Chemistry		**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The course is fully consistent with the CHEM-02/A declaration in the following points: The group deals with the study and development of theoretical, computational and experimental models and methodologies for the interpretation and prediction of the behavior of complex systems, as well as the preparation of materials, including molecular ones, in the fields in which chemical sciences operate, and in those in which molecular interpretation is required. In particular, the skills concern the fields of nanosystems, liquid and solid state including interphases, "soft" matter and synthetic and biological macromolecules		
Learning objectives: The course aims to introduce the student to the knowledge of soft matter and nanostructured systems. The course deals with the study of intermolecular interactions, colloidal systems, interphase properties and self-assembling systems, evaluating thermodynamic and kinetic aspects, and with particular attention to the structural characteristics and experimental methodologies used for the structural analysis of these systems. The course also aims to present the student with an overview of the fields of application, ranging from food technology to medicine, of nanostructured and "soft" systems, with reference to possible environmental and biological impacts.		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		
Types of exams and other tests: Oral exam		

Teaching: **STRUCTURAL CRYSTALLOGRAPHY**	**Course language:** English
SSD: CHEM-03/A – General and Inorganic Chemistry	**CFU:** 6
Course year: I or II	**Type of Training Activity:** Related or complementary
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: the structural characterization of compounds of the main groups, transition series, lanthanides and actinoids, as well as coordination compounds and inorganic, bio-inorganic, supramolecular and nanostructured materials.	
Learning objectives: Basic knowledge of the mathematical theory of crystal symmetry. Basic knowledge of X-ray physics (production and detection), of the physics of X-ray diffraction from crystals and of mathematical methods for the determination of atomic coordinates and other atomic parameters from X-ray diffraction intensity data. Ability to logically and analogically understand a crystal structure: analysis of molecular geometry, analysis of crystalline packaging in terms of strong directional interactions (hydrogen bonding, halogen bonding, chalcogen bonding) and weak intermolecular interactions. Basic elements of *crystal engineering*, with particular regard to the concept of supramolecular syntone.	
Prerequisites for entry: NONE. **Prerequisites for exit:** NONE**.**	
Types of exams and other tests: Oral exam**.**	

Elective courses (common to the two curricula)

Teaching: **DIDACTICS OF CHEMISTRY**	**Language of delivery:** Italian
SSD: CHEM-03/A – General and Inorganic Chemistry	**CFU:** 6
Course year: **I or II**	**Type of Educational Activity:** Optional
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: CHEM-03/A : "The sector is also interested in teaching methodologies and the history of chemistry"	

Learning objectives:
The course aims to provide students with the tools to effectively deal with aspects related to the teaching of chemical disciplines in secondary schools and/or university courses. At the end of the course students will be able to:
•present and discuss the main theoretical frameworks developed for the teaching of chemistry, together with methodologies and techniques for the didactic transposition of the conceptual nodes of the discipline, with particular reference to the issues that can be addressed in upper secondary school and university courses in General and Inorganic Chemistry and Laboratory;
•design, present and discuss examples of educational paths based on active teaching methodologies (e.g. Open Inquiry), laboratory teaching, resources and multimedia technological tools specific for the teaching of chemistry;
•critically discuss the pedagogical relationship between the founding concepts of chemistry at the macroscopic, microscopic and symbolic level and their didactic transposition;
•discuss the relationship of chemistry with other disciplines, highlighting their specificities in terms of conceptual structure and cognitive approach to reality, and the relations of the discipline with society (environment, health, food, energy, circular economy, new materials, conservation of cultural heritage);
•present and discuss methods of self-assessment and evaluation of the knowledge and skills acquired;
•to provide criteria and tools for the design of educational activities related to chemistry according to the training objectives and the level of education in which one operates.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **STRUCTURE AND DYNAMICS OF BIOLOGICAL MACROMOLECULES**	**Language of delivery:** Italian
SSD: CHEM-02/A - Physical Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional

Procedure:
In presence.

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The CHEM-02/A sector deals with the study and development of theoretical, computational and experimental models and methodologies, ..., for the interpretation and prediction of the behavior of complex systems, ..., in the fields of ... in which molecular interpretation is required. In particular, the competences concern the fields ... and synthetic and biological macromolecules, ... Thermodynamics, ..., spectroscopy, electron microscopy ... allow the characterization and interpretation of the properties of complex systems and their temporal evolution ...

Learning objectives:

The aim of this course is to provide the chemical-physical bases of the methods that allow to unravel the structural organization of biological macromolecules (proteins, nucleic acids and their complexes). Through lectures and practical exercises, students will learn how the use of a series of complementary techniques allows to build structural models on different scales of resolution and obtain information on the dynamics of the systems under consideration. Students will delve into the fundamentals of various structural methodologies, including X-ray crystallography, cryo-EM, small-angle X-ray scattering, and several spectroscopies.
Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **BIONANOTECHNOLOGY**	**Language of delivery:** Italian
SSD: BIOS-07/A - Biochemistry CHEM-07/C – Fermentation Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional
Procedure In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The study and development of innovative methods, processes and products, including on a nano scale, for the production and processing of chemicals of natural and synthetic origin, as well as their biotechnological applications in the biomedical, pharmaceutical, agri-food, veterinary, industrial and environmental fields, are an integral part of the BIOS-07/A and CHEM-07/C sectors.	
Learning objectives: The student will acquire knowledge on the association of biomolecules to nanomaterials/nanostructured materials; on the method of implementation and properties of nanobiotechnological systems; on biotechnological processes for the production of micro and nanostructured biomaterials. Examples of applications in the environmental, pharmaceutical and food fields will be presented.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching:	**Language of delivery:**

CHEMISTRY OF ORGANIC DYES	Italian
SSD: CHEM-05/A - Organic Chemistry	**CFU:** 6
Course year: **I or II**	**Type of Educational Activity:** Optional
Procedure: in presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: the proposed course is fully consistent with the CHEM-05/A declaration in the points: - "the development of efficient, sustainable and environmentally friendly synthesis methodologies" - "the elucidation of the mechanisms through which organic compounds are formed and transformed both in the laboratory and in natural and environmental systems" - "of the design, chemical synthesis of compounds of organic materials"	
Learning objectives: The student acquires the knowledge of: theory of color perception and in particular the knowledge of the physical, chemical and physiological aspects of the color perception process; history of natural and synthetic dyes; structure and synthesis of synthetic dyes and their application in different sectors. Ecology and toxicology of dyes.	
Prerequisites for entry: NONE **Prerequisites for exit:** NONE	
Types of exams and other tests: Oral exam	

Teaching: **GLYCOCOMICS**	**Language of delivery:** English
SSD: CHEM-05/A- Organic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: This course complies with the CHEM-05/A declaration in the following cases: - … Scientific and educational activity in the field of the study of carbon compounds, both of natural and synthetic origin, including biomolecules and their mimetics, and polymers. - The following are the subject of study: ... their supramolecular interactions, the structural characterization of the organic substances under study and the structure-reactivity relationships. - It deals with the isolation of organic substances of animal, plant and marine origin, also with biological activity, and the determination of their structure. - He also deals with the design and chemical synthesis of biologically active compounds.	

Learning objectives:
At the end of the course the student will have learned: a) the chemical structure of monosaccharides, their classification and reactivity, b) the structure of some natural oligosaccharides and polysaccharides, c) bacterial polysaccharides, the biological role and their use in the environment. Characteristics and biosynthesis. Elements of glycobioinformatics: main databases and methods of use. In silico examples on the structural elucidation of carbohydrates by GC-MS and NMR.
EXPECTED LEARNING OUTCOMES: Making judgements: the student must be able to a) recognize the monosaccharides present in a complex glycan, b) know the architecture of bacterial cell membranes and their immunological implications, c) the structure of glycans in glycoproteins and, where known, their role. Knowledge in the application of NMR and GC-MS to carbohydrates.
Communication skills: The student will have to demonstrate a) to be able to clearly illustrate, exemplifying them appropriately, the rules, conventions, technical terminology and notations of glycocomics; b) to have understood the interdisciplinary nature of the subject and to be able to illustrate the potential and fields of application even to non-experts.
Learning skills: The student must have an understanding of: a) a scientific text or article in English relevant to the topics covered during the course; b) scientific seminars or thematic congresses on carbohydrates.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam

Teaching: **METHODOLOGIES OF INVESTIGATION FOR THE ENVIRONMENT AND THE CULTURAL HERITAGE**	**Language of delivery:** Italian
SSD: CHEM-01/B – Chemistry of the Environment and Cultural Heritage	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The contents are consistent with the declaration of the CHEM-01/B sector which deals with the development and application of diagnostic methods for the characterization of environmental matrices and of historical-artistic interest and sustainable interventions for the monitoring and speciation of pollutants, their characterization in the environment and in the historical-artistic heritage.

Learning objectives:
The course aims to provide the student with the technical knowledge for the analysis of complex environmental matrices and the diagnostics of the artistic-historical heritage. The cutting-edge metrologies in the field will be described with reference to examples from the literature (5CFU) and some laboratory exercises (1CFU) will be proposed.

Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **ADVANCED METHODOLOGIES FOR THE CHARACTERIZATION OF ORGANIC COMPOUNDS**	**Language of delivery:** Italian
SSD: CHEM-05/A - Organic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional
Procedure: In presence	
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The proposed course is fully consistent with the CHEM-05/A declaration in the points: -"The following are being studied.....the structural characterization of the organic substances under study and the structure-reactivity relationships." -"It deals with the isolation of organic substances ..... the determination of their structure, including stereochemistry, as well as the development of methods suitable for this purpose."	
Learning objectives: Through a theoretical-practical approach, the course aims to provide students with the ability to determine the structure of organic molecules of medium complexity, through the joint interpretation of spectral data obtained by 1H and 13C-NMR, MS, IR techniques And UV and, when necessary, through 2D-NMR SPECTRA (COSY, HMQC, HMBC, NOESY). The principles theoreticians of the above techniques will be treated in detail. Particular emphasis will be given to the study of the nuclear magnetic resonance of the proton and 13C. The experimental aspects concerning the recording, transformation and analysis of the 1H and 13C-NMR spectra will also be discussed. The determination of stereochemical details of organic molecules will be studied (NOE effect and NOESY spectra), also through the analysis of specific cases extracted from the literature or from studies carried out by the teacher. At the end of the course the student must have knowledge of the theoretical principles underlying the 1H- and 13C-NMR, MS, IR and UV techniques. He must be able to use the fundamental parameters and information that each of these techniques provides for the structural determination of unknown organic compounds. Show that you know basic 2D-NMR techniques and how to interpret 2D-NMR spectra. To be able to determine the structure of organic compounds of medium complexity through the joint use of such techniques. The student must be able to illustrate with clarity and appropriate language the techniques learned and the information they are able to provide in structural resolution The student must also demonstrate that he or she is able to independently choose the most appropriate structural investigation techniques that can provide him with the information sought on an unknown compound and to be able to develop a logical reasoning through which he can arrive at the solution of stereostructural problems.	

Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Teaching: **MOLECULAR MODELING AND DATA SCIENCE FOR CHEMISTRY**	**Language of delivery:** Italian	
SSD: CHEM-02/A- Physical Chemistry		**CFU:** 6
Course year: I or II	**Type of Educational Activity:** optional	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The course is fully consistent with the CHEM-02/A declaration in the points: study and development of theoretical, computational and experimental models and methodologies for the description, interpretation and prediction of the behavior and properties of complex chemical systems. In particular, the skills concern the atomic, molecular, [...] synthetic and biological macromolecules, and areas such as materials science, biomedical sciences, energy and cultural and environmental heritage, including the study of natural and anthropogenic systems, with models for sustainability and the circular economy. Thermodynamics, spectroscopy, computational modeling allow the characterization and interpretation of the properties of complex systems and their temporal evolution.		
Learning objectives: The course is designed to provide students with the cultural foundations and essential knowledge of methods and applications in the fields of theoretical and computational chemistry, artificial intelligence, data science in chemistry and immersive molecular graphics. Methods such as molecular dynamics simulations and *machine learning* algorithms are introduced and used to model chemical reactions, predict structural and dynamic properties of molecules, simulate and interpret spectroscopic signals and molecular magnetic spectroscopies (IR, Raman, UV-vis, fluorescence, NMR, EPR, imaging). Quantum mechanical methods and data science techniques based on statistical analysis and programming are briefly introduced as promising supports in important fields of experimental chemistry. A large part of the course is dedicated to laboratory simulations concerning a wide range of applications that include the study of molecules involved in the origin of life, *drug discovery* and *drug delivery* in biomedicine, automated molecular recognition, simulation of essential reactions in biochemistry, materials science, energy storage, development of electronic instruments, such as electron and proton transport in complex environments.		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		

Types of exams and other tests: Oral exam

Teaching: **PRODUCTS AND PROCESSES OF THE INDUSTRIAL CHEMISTRY**		**Language of delivery:** Italian
SSD: CHEM-04/A – Industrial Chemistry		**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The scientific disciplinary group is interested in scientific and didactic-training activities in the field of science and technology for the sustainable industrial development of chemical products, materials and processes and for energy, through the definition of principles and the study of thermodynamic, kinetic, catalytic and technological aspects [..]. It deals with sustainable development, and the optimization and management of industrial processes with particular attention [...] to the structure and integration of industrial production in the chemical sector [...].		
Learning objectives: The aim of the course is to provide the student, in a specialized way, with the appropriate methodological knowledge and tools, also through the analysis of Case Studies, to address and solve conceptual and design problems concerning the main organic/inorganic products of the chemical industry and the related industrial processes.		
Prerequisites for entry: NONE **Prerequisites for exit:** NONE		
Types of exams and other tests: Oral exam		

Teaching: **METALLOENZYMES: FROM DIAGNOSTICS TO SUSTAINABILITY**		**Language of delivery:** English
SSD: CHEM-03/A – General and Inorganic Chemistry		**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional	
Procedure: In presence		
Contents extracted from the SSD declaration consistent with the educational objectives of the course: The educational objectives of the course are consistent with the following contents extracted from the SSD declaration: "The study, the general areas of interest and the use of knowledge, relating to the chemical properties of elements and their compounds, consider levels ranging from basic		

research to applications in all sectors of chemistry, including energy, with attention to issues related to sustainability and circularity".

Learning objectives:
The aim of the course is to provide advanced knowledge on the main natural and artificial metalloenzymes that can be used in the development of sustainable technologies. The student will develop the following skills and knowledge: (a) understand the fundamental concepts of circular economy; (b) understand the biological processes, reactions and catalysts involved in the production and storage of energy from renewable sources, carbon/nitrogen fixation, biomass repurposing, environmental remediation; (c) recognize the main techniques for the development of bioinspired catalysts; (d) access technologies and methodologies for the immobilization of reporter molecules for the development of bioreactors and biosensors.

Prerequisites for entry:
NONE
Prerequisites for exit:
NONE

Types of exams and other tests:
Oral exam.

Teaching: **SUPRAMOLECULAR CHEMISTRY**	**Language of delivery:** English
SSD: CHEM-05/A – Organic Chemistry	**CFU:** 6
Course year: I or II	**Type of Educational Activity:** Optional

Procedure:
In presence

Contents extracted from the SSD declaration consistent with the educational objectives of the course:
The course is fully consistent with the CHEM-05/A declaration, in particular with regard to: "the development of efficient, sustainable and environmentally friendly synthesis methodologies also based on (stereo)selective and catalytic approaches, including organo-bio- and enzyme-catalytic ones, the elucidation of the mechanisms through which organic compounds are formed and transformed both in the laboratory and in natural and environmental systems, their supramolecular interactions." Other relevant topics are: "biologically active compounds, organic materials, supramolecular systems, polymers and bio-polymers, ... study of new catalysts with reference also to their development in application areas."

Learning objectives:
The aim of the course is to introduce the student to the basic concepts of supramolecular chemistry and to the main methodologies of synthesis and characterization of supramolecular systems, as well as to their applications for molecular recognition. In particular, host-guest systems based on corona ethers, cavitands, cryptands, spherands, lariate ethers, calixarenes, cyclodextrins, self-assembling and biomimetic systems, molecular sensors and molecular machines will be discussed.
At the end of the course the student will be able to critically discuss, also through the presentation of literature articles, the main supramolecular systems, with particular attention to biomolecules, and the synthetic strategies adopted for the preparation and functionalization of the most common host systems.

Prerequisites for entry: NONE **Prerequisites for exit:** NONE
Types of exams and other tests: Oral exam

Curricular internship activities

The Regulations of the Degree Course provide for external internship activities at affiliated institutions and companies and orientation for a total of 6 credits (150 hours), aimed at acquiring useful knowledge for approaching the world of work and facilitating future professional choices through direct knowledge of the work sector to which the qualification can give access.
Job-oriented seminar activities are also planned.
The procedures relating to the performance and acquisition of credits for these activities are reported on the website of the CdS (**http://www.scienzechimiche.unina.it/LMSC/tirocini1**)

FINAL EXAM

The Master's Degree in Chemical Sciences is obtained after passing all the exams required by the system together with a final exam, consisting of the discussion of a thesis on a specific topic previously agreed with at least one supervisor who will supervise the activity in its various phases. The experimental activity may be carried out both within the university structures and at research centers, companies or external bodies, according to the procedures established by the teaching structures.
The thesis must consist of an original paper developed independently by the student on the basis of an experimental laboratory activity focused on problems and methodologies of scientific research and aimed at achieving the ability to work autonomously experimentally, acquire and process data, discuss and critically present the results and the international scientific literature.
The thesis project, agreed with the supervisor, is proposed to a special Commission designated by the Course which identifies two co-supervisors with scientific experience relevant to the topic presented. The student publicly describes the essential lines of his thesis project during a public seminar (Pre-Degree Seminar), to which 6 CFU are attributed. From the date of the pre-graduation seminar, about 6 months must pass before the final discussion of the thesis. The two co-examiners follow the work of the graduating student through periodic interviews, receive a copy of the final paper on time and express their opinion in the graduation session.
The final paper, which can be written in English, includes the presentation and interpretation of the results obtained, together with a framing of the work carried out in the appropriate cultural context and scientific literature.
The candidate presents and discusses the thesis work in a public graduation session in the presence of a Commission appointed by the teaching structures.
The final grade, expressed in one hundred and tenths with the possibility of honors, is established on the basis of the thesis work, its presentation, and previous career.

External training periods – ERASMUS and DUAL DEGREE programmes

The Degree Course in Chemical Sciences supports and encourages the national and international mobility of its students, offering the opportunity to spend periods of study and internship abroad.
Further information, including the agreements already activated, can be found *here*.
In addition, the degree course has active training courses aimed at issuing a double university degree (Dual Degree). For more information, consult the website of the course of study or contact the coordinator.