CHEMISTRY

FACULTY OF SCIENCE

UNIVERSITY OF ZARAGOZA

INDEX

INTRODUCTION

FACULTY OF SCIENCE

The Faculty of Science is located at the heart of Zaragoza city, in San Francisco Campus. It has a long history of excellence in teaching and research. The Faculty has a strong international profile and attracts students from Europe and around the world. With more than 1,000 ISI journal articles published per year, the Faculty is a leading research hub at the University of Zaragoza, ranked among the top 200 world-class universities for Natural Sciences & Mathematics (ARWU 2016).

Figures for the Faculty of Science:

- 1850 students
- 450 professors + 100 researchers + 100 support staff
- 40 classrooms + 20 teaching labs + 150 research labs + 9 computer classrooms

Undergraduate Degree Programs

- BSc in Biotechnology
- BSc in Chemistry
- BSc in Geology
- BSc in Mathematics
- BSc in Optics and Optometrics
- BSc in Physics

MSc Degree Programs

- MSc in Geology: Techniques and applications
- MSc in Industrial Chemistry
- MSc in Mathematical modelling and research, Statistics and Computation
- MSc in Molecular and Cellular Biology
- MSc in Quantitative Biotechnology (***in English***)
- Msc in Molecular Chemistry and Homogeneous Catalysis
- MSc in Physics and Physical technologies
- MSc in Nanostructured Materials and Nanotechnological Applications (***in English***)
- MSc Erasmus Mundus in Membranes Engineering (***in English***)

English-language friendly (ELF) modules

Three of our MScs are taught in English, while the rest of MScs and all the BScs are taught in Spanish. In the programs taught in Spanish, most of the modules are English-language friendly. This means that, in those modules, foreign students will have, upon request:

- Learning material in English.
- Office hours in English.
- Assessment (exams, homework...) in English.

In the list of modules for each program, see below, English-language friendly modules for 2018/2019 are marked with an ELF label. The list of ELF modules may change slightly by 2019/2020; a list for that year will be available some weeks before of the start of the classes.

High level research: More than 1.000 research papers in JCR per year

The Faculty has been the seed of Research Institutes of the University of Zaragoza:

- BIFI: Institute of Biocomputation and Physics of Complex Systems
- ICMA: Aragon Materials Science Institute
- INA: Institute of Nanoscience of Aragon
- ISQCH: Institute of Chemical Synthesis and Homogeneous Catalysis
- IUCA: Environmental Science Institute of Aragon
- IUMA: Institute of Mathematics and Applications

Most professors/researchers in the Faculty of Science are members of these institutes.

BSc IN CHEMISTRY

Duration: 4 years full time. 60 ECTS per year.

Language: Spanish.

Program aims:

The Bachelor's Degree in Chemistry at the University of Zaragoza aims to provide the future chemist a solid interdisciplinary scientific training, ability to solve problems and to promote pragmatism and flexibility to meet the demands required by the profession. To do so, the student has the material and human resources that led to the teaching and research staff in Chemistry at the University of Zaragoza to be recognized nationally and internationally at the first level. Students in this degree are aimed to learn the composition, structure, properties and reactivity of matter, together with the theoretical fundaments that determine them and to be able to apply this knowledge to the scientific, technological and cultural development of our society.

Structure:

Year 1. In the first year students must enrol in the following modules:

Module	ECTS	Semester
27200 - General Chemistry	15	YL
27201 - Introduction to The Chemistry Laboratory	9	YL
27202 - Mathematics	12	YL
27203 - Physics	12	YL
27204 - Biology	6	S1
27205 - Geology	6	S2

S1: Semester 1. Mid-September to mid-January
S2: Semester 2. Beginning-February to end-May
YL: Year-long. Mid-September to end-May
ELF: English-language friendly module (see first page)

Year 2. In the second year students must enrol in the following modules:

Module	ECTS	Semester
27206 - Analytical Chemistry I[ELF]	9	YL
27207 - Physical Chemistry I	10	YL
27208 - Inorganic Chemistry I[ELF]	9	YL
27209 - Organic Chemistry I[ELF]	9	YL
27210 - Chemistry Laboratory	12	YL
27211 - Statistics and IT[ELF]	6	S1

In this second year they must also select one module from:

Module	ECTS	Semester
27224 - History of Science[ELF]	6	S2
27225 - Introduction to Management Systems	6	S2

Year 3. In the third year students must enrol in the following modules:

Module	ECTS	Semester
27212 - Analytical Chemistry II[ELF]	12	YL
27213 - Physical Chemistry II[ELF]	11	YL
27214 - Inorganic Chemistry II[ELF]	12	YL
27215 - Organic Chemistry II	12	YL
27216 - Fundamentals of Chemical Engineering[ELF]	6	S1
27217 - Biochemistry[ELF]	7	S2

Year 4. In the fourth year students must enrol in the following modules:

Module	ECTS	Semester
27218 - Materials Science[ELF]	7	YL
27219 - Structure Determination[ELF]	6	S1
27220 - Laboratory Methods and Quality Control[ELF]	6	S1
27221 - Spectroscopy and Molecular Properties[ELF]	6	S1
27222 - Chemical Industry: Processes, Hygiene and Safety[ELF]	6	S2
27223 – Undergraduate Dissertation *[ELF]	9	YL

In this fourth year they must also select four modules from the list of optional modules:

Module	ECTS	Semester
27226 - Environmental and Toxics Analysis[ELF]	5	S2
27227 - Non-Destructive Analysis of Solid Materials	5	* *
27228 - Fast-response Anatytical Methods[ELF]	5	S2
27229 - Environmental Physical Chemistry and Photochemistry	5	* *
27230 - Introduction to Molecular Modeling[ELF]	5	* *
27231 - Nuclear Chemistry: Physicochemical Properties of Drugs and Radiopharmacy[ELF]	5	S2
27232 - Homogeneous Catalysis [ELF]	5	S2
27233 - Environmental Inorganic Chemistry	5	* *
27234 - Organometallic Chemistry[ELF]	5	S2

27235 - Organic Chemistry Insights[ELF]	5	S2
27236 - Characterization and Instrumental Techniques for Organic Chemistry	5	* *
27237 - Industrial Organic Chemistry[ELF]	5	S2
27238 - Industrial Biochemistry and Microbiology	5	* *
27239 - Environmental Technology[ELF]	5	S2
27240 - Biological Activity of Chemical Compounds[ELF]	5	S2
27241 – Internship	5	S2

Not all the optional modules are available every year. A list of the available modules for the following year (starting in September) is published in June. The modules with ** in the Semester column are not being offered in 2018/2019.

*Undergraduate Dissertation

Undergraduate Dissertation (UD) is a 225 hour work. It is undertaken during the 4th year. The student is supervised by a professor who defines the objectives of the Project and guides him/her along the work. Students must write a report and deliver a public presentation of it. The following list includes some examples of UDs performed in the last years:

- Direct determination of metals in air-filters by laser techniques.
- Study of the aggregation of silver nanoparticles in biological environment by gel electrophoresis and laser ablation-ICP-MS.
- Development of an enzymatic optical biosensor for the determination of hydrogen peroxide.
- Study of the release of silver in nanomaterials by atomic spectrometry techniques.
- Looking for nanoparticles, selectivity and sensitivity.
- Study of the formation of reduced aromas from amino-acid precursors. Catalytic effect of the metals.
- Digital images in analytical determinations: Study of the illuminant.
- Study of the potential of high-resolution continuous source for the detection of nanoparticles in graphite furnace.
- Preparation and characterisation of nanostructured materials with highly conjugated organic compounds with application in molecular electronics.
- Thermophysical study of liquid mixtures containing an ionic liquid and a polar solvent.
- Incorporation of organometallic compounds in electronic devices.
- Generation of micro and nanoparticles of ecological phytosanitary compounds.
- Computational study of the reaction mechanism of Ru-bypyridine compounds with anticancer activity.
- Synthesis and characterization of metal-phosphazenes with catalytic properties.
- Synthesis and characterization of complexes of gold (I) and gold (III) with biological ligands.
- Synthesis of complexes with fluorescent ligands. Changing the light emission through their coordination to different metals.
- Homogeneous catalysis for preparing functional polymers.

- Synthesis of organometallic complexes focused on the activation of molecular Nitrogen.
- Nickel organometallic compounds: Synthesis, characterization and properties.
- Luminescent metal complexes with applications in therapy and bioimaging.
- Synthesis of gold compounds with anticancer activity and study of their properties.
- Synthesis of compounds of Cu, Ag and Au with biological activity.
- Synthesis of aromatic amino acid mediated by organometallic compounds of palladium.
- Biorefinery: obtaining products with high added value
- Organic dyes for third generation-solar cells: a real alternative to silicon panels
- Enantioselective catalysis.
- Glycomimetics of biological and pharmacological importance.
- Preparation of block copolymers and polymeric nanoparticles in water for use in controlled drug release.

MSc IN NANOSTRUCTURED MATERIALS AND NANOTECHNOLOGICAL APPLICATIONS

Duration: 1 year full-time programme. 60 credits (ECTS).

Language: English.

Program aims:

The course is multidisciplinary and aims to provide students with fundamental knowledge, practical experience, and skills to become a practitioner in Nanotechnology, whether in industry, research or academia.

The course is suitable for graduates with science, engineering or related degrees keen to develop careers at the forefront of Nanoscience and Nanotechnology. Our one-year Master´s programme focuses on the creation and study of nanostructured materials and devices by directly controlling matter on the nanoscale. More precisely, students will take a number of specialized courses involving lectures, laboratory practical work and seminars on fabrication, assembly and characterization of nanostructured materials and devices. The intended learning outcomes include communication and lifelong learning skills.

The course is completely taught in English by highly qualified members of research and academic staff within the INA, ICMA, and the Faculty of Science of Zaragoza University as well as by other national and international departments and industrial representatives.

This Master's programme offers you access to state-of-the-art facilities, such as the Advanced Microscopy Laboratory, LMA, with the most advanced infrastructures in Nanofabrication, Local Probe and Electron Microscopies for the observation, characterization, nanopatterning and handling of materials at atomic and molecular scale.

Structure:

The master comprises six core modules (36 ECTS credits) which include lectures, tutorials, practical work in the laboratory, and case studies. In addition, the student will choose two out of the four optional modules offered (10 ECTS credits), depending on his/her professional, academic or research interests. The course also includes an individual research project (14 ECTS credits). The students will select the individual project in consultation with the Course Director. The project will be related to the student background degree and research or professional interests.

Module	ECTS	Semester
66100 - Fundamental Properties of Nanostructured Materials	6	S1

66114 - Characterization I: Physical-chemical Techniques	6	S2
66104 - Characterization II: Advanced microscopies	6	S2
66112 - Preparation of Nanostructured Materials	6	S1
66111 - Assembly and Fabrication of Nanostructures	6	S1
66106 - Case Studies of Industrial Applications	6	S1
66118 – Master's Dissertation *	14	YL
66113 - Introduction to Research in Nanoscience	5	S1
66116 - Fabrication of Micro and Nanodevices	5	S2
66115 - Multidisciplinary Joint Educational Project	5	S2
66117 - Intership	5	

*Master's Dissertation

The Master's final project Dissertation (MD) is a 350 hours compulsory project on any topic of relevance to the current scientific and technological context and it is commonly carried out in one of the research groups involved in the Master´s programme.

The following list includes some of the Master's final project proposals offered on past editions:

- Analysis of proteins by local probe microscopy
- Assembling a toolbox of magnetic nanoparticles for magnetic hyperthermia applications
- Au-SiO_2 plasmonic nanostructures for SERS detection applications in gas phase
- Chemical modification of surfaces for molecular electronics applications
- Development of layered semiconductor-carbon composites for energy storage devices (supercapacitors and rechargeable batteries)
- Development of responsive nanostructured supramolecular materials based on bent-core molecules
- Elaboration and study of 2D films based on metalloporphyrins
- Elaboration and study of 2D nanoparticle assemblies by Langmuir-Blodgett
- Elaboration and study of covalent organic frameworks
- Engineering hybrid catalysts containing metal oxide clusters for energy-related applications
- Fabrication and applications of MOP ultrathin films obtained by the Langmuir-Blodgett (LB) method
- Fabrication and characterization of nanocomposite Ni/HfO_2 granular multilayers
- Fabrication and electrical characterization of graphene nanodevices
- Fabrication of microfluidic SERS devices by nanoimprint lithography techniques for CWAs detection in gas phase
- Fabrication of molecular electronic devices using simple chemical procedures

- Fabrication of superconducting $YBa_2Cu_3O_7$ quasi-monodimensional microwires by a chemical solution method
- Immobilization of MNPs on cell membranes via cadherins for magnetic hyperthermia studies
- In-situ TEM investigations of 1D and 2D Nanomaterials
- Intrinsic and extrinsic effects on the transport properties of nanodevices based on Topological Insulators
- Localized magnetic hyperthermia as a novel tool for cell transfection
- Magnetic hyperthermia based nanotherapies
- Microencapsulation of eukaryotic and prokaryotic cells within alginate beads using microfluidics
- Microfluidic approach to the green synthesis of covalent organic frameworks
- Nanofabrication of two dimensional chemical scaffoldings
- Nanopatterning of molecules on devices by Atomic Force Microscopy
- Nanostructured analytical biosensors for the detection of emerging contaminants
- New colloidal nanocrystalline semiconductors for solar cells
- New solar-light-active photocatalysts for persistent organic pollutants (POPs) removal in wastewater
- Optimized nanocarriers from amphiphilic block copolymers by supramolecular chemistry
- Particle engineering in metal organic framework ZIF-8
- Pegylated pH-sensitive micelles based on polypeptides for biomedical applications
- Photodynamic therapy in the treatment of skin-associated infections
- Photoresponsive gene delivery vectors: synthesis, characterization and application
- Preparation and characterization of nanostructures of pyrene-containing bent-core molecules by self-assembling techniques
- Pt-based deposits grown in cryogenic conditions by Focused Ion Beam Induced Deposition (Cryo-FIBID) for applications in Nanoscience
- Study of the antimicrobial and antioxidant properties of magnesium oxide nanoparticles and their potential for the development of new active food packaging solutions
- Synthesis and Advanced Transmission Electron Microscopy characterisation of $AgBiS_2$ nanoparticles for photovoltaics: influence of nanostructure on solar cell performance
- Synthesis of covalent nanostructures on functional surfaces
- Synthesis of electrospun oxide fibers for catalytic applications
- Understanding ferroelectricity in HfO_2-ZrO_2 films

MSc ERASMUS MUNDUS IN MEMBRANES ENGINEERING

Duration: 2 years full time. 120 ECTS.

Language: English.

Program aims:

The main objective of the curriculum proposed in this EM3E Master's Program is to promote excellence, innovation, mobility and diversity in high-quality courses related to membrane science and engineering at the interface between material science and chemical engineering. Students will be taught by internationally recognized specialists who are deeply involved in this field both at scientific and at industrial levels. The goal is to acquire theoretical knowledge in the fields of project management, quality environmental legislation, communication and language, as well as apply it during practical session in the laboratory. Subjects cover diverse contents related to membranes technology and their application in different fields such as Biotechnology, environmental sciences, energy and health.

Structure:

The Master's Degree in Membrane Engineering EM3E offers an advanced education program and focuses on specific applicable fields. It involves 6 Higher Education Institutions of 5 European countries:

Université Montpellier 2 (France), coordinating organisation,
Université Paul Sabatier (Toulouse, France),
Institute of Chemical Technology Prague (Czech Republic),
Universidade Nova de Lisboa (Portugal),
Universidad de Zaragoza (Spain),
University of Twente (Netherlands).

The program spreads over 2 years (120 ECTS, 4 semesters). The courses provided in the four semesters, S1-S4, bridge different scientific domains like material science, physics & chemistry, engineering & processes, while keeping a focus on relevant applications of membranes in food and health industry, industrial and chemical processing, energy, environmental control, pharmaceutical industry, biomedical applications, etc.

The first year of the Master's Degree has been designed to allow the acquisition of required bases: theoretical and practical fundaments in materials science, physics, chemistry and chemical engineering are provided. After a welcome week and the month of September devoted to the common courses at the Université Montpellier 2**,** the students are distributed in two tracks:

- Students with a bachelor background in chemical engineering (about a half part of the enrolled students) study the first semester (S1) at the Université

Montpellier 2, focused on fundamentals of materials science.

- Students with an initial background knowledge in chemical engineering (the other half part of the enrolled students) study semester S1 at the Université Paul Sabatier, given it is specialised in chemical engineering fundaments.

In the second semester (S2), students follow all together mandatory teaching units to acquire knowledge and skills on process modelling and simulation in the Institute of Chemical Technology of Prague (Czech Republic).

The second year starts with a third semester S3 devoted to one application field. Students are divided in three groups (under criteria of the student's choice and the student's grades in the semester S1) to get advanced courses in one of the following mobility options:

- Biotechnologies, Food and Health, at the University of Lisboa (UNL), Portugal.
- Nanoscience and Nanotechnology, at the University of Zaragoza (UNIZAR), Spain.
- Energy and Environment, at the University of Twente (UTwente), The Netherlands.

The **fourth semester** (S4) is devoted to a 6 months master thesis project in a university (for student aiming to undertake a PhD) or in an industrial company (for students aiming to get immediate employability after the Master's Degree).

For further details on the organization of the MSc, access:
http://em3e.eu/the-master-em3e

The following list includes the different modules students can enrol in each year.

Modules (first year)	**ECTS**	**Semester**
Curricula students at Université Montpellier 2 – Materials Science		
Structural and microstructural characterization of solids	3	S1
Characterization of porous materials	3	S1
Inorganic materials	3	S1
Polymer materials	3	S1
Hybrid and composite materials	3	S1
Materials for chemical reactions/heterogeneous catalysis	3	S1
Curricula students at Université Paul Sabatier – Chemical Engineering		
Characterization of porous materials	3	S1
Transport phenomena	3	S1
Thermodynamics, kinetics and reactivity	3	S1
General chemistry and physico-chemical analytical methods	3	S1
Colloid and surface engineering	3	S1

Structural characterization of solids	3	S1
All the students semester 1		
International and European Working Law and Environmental Law	2	S1
Safety, Security, Health and Environmental requirements for a sustainable chemistry	2	S1
Quality Assurance and Laboratory Practice	2	S1
Individual project (bibliographic and experimental study)	6	S1
French language and culture (optional)	2	S1
Institute of Chemical Technology Prague		
Membrane processes	4	S2
Process design	5	S2
Applied reaction kinetics	4	S2
Separation Technology	5	S2
Individual project (bibliographic and experimental study)	6	S2
Intellectual capital management	3	S2
Valorisation, commercialisation and enterpreneurship	3	S2

Modules (second year)	**ECTS**	**Semester**
Biotechnologies, Food and Health (Universidade Nova de Lisboa)		
Membrane contactors and bioreactors	6	S3
Membranes in downstream processing	6	S3
Barrier membranes for food applications	6	S3
Membranes in regenerative medicine	6	S3
Individual project (bibliographic and experimental study)	6	S3
Nanoscience and Nanotechnology (Universidad de Zaragoza)		
Fundamental properties of nanostructured materials	6	S3
Preparation of nanostructured materials	6	S3
Assembly and fabrication of nanostructures	6	S3
Case studies of industrial applications	6	S3
Individual project (bibliographic and experimental study)	6	S3
Spanish Language and Culture	2	S2
Nanoscience and Nanotechnology (University of Twente)		
Batteries, fuel cells an electrolysers	5	S3
Gas separation membranes and gas treatment	5	S3
Water treatment	5	S3
Membrane process plant design	5	S3
Microdevices and sensors	4	S3
Individual project (bibliographic and experimental study)	6	S3
Final Master Project in Universities of the consortium or companies		
Master's Dissertation*	30	S4

*Master's Dissertation

The Master's Dissertation (MD) is a 750 hour compulsory project carried out during 6 months in a university (for students aiming to undertake a PhD) or in an industrial company (for students aiming to get immediate employability after the master's Degree). It is undertaken in the second semester of the second year. The following list includes some examples of MDs performed in the last years:

- 3D structuration of MOF layers for gas sensors enhancement and its application in microreactors.
- Development of gas/liquid catalytic membrane reactor.
- Silicon carbide-based capillary membranes for gas separation and water treatment.
- Novel Ion selective membranes.
- Separation and fractionation of nanoparticles in solutions by membranes.
- Axial development of nanoparticle fouling in hollow fiber microfiltration membranes.
- Membrane operation in the treatment of produced water: An experimental study.
- Stimuli responsive (Smart) composite polymer membranes to solve fouling.
- Thin film nanocomposite MOF based membranes by interfacial polymerization for gas separation and pervaporation.
- Development of hemocompatible microdevices for oxygenation.

MSc IN MOLECULAR CHEMISTRY AND HOMOGENEOUS CATALYSIS

Duration: 1 year full time. 60 ECTS.

Language: Spanish.

Program aims:

This Master Program is aimed to train researchers with suitable skills for their integration both in the academic area and in R+D+i departments of chemical companies, by acquiring current knowledge in chemical synthesis and catalysis and to ptovide extensive use of the most advanced techniques and software for the structural characterization, monitoring of processes, theoretical molecular modelling, as well as information retrieval tools from chemistry data bases and bibliographic resources.
This Master's Degree provides advanced training in molecular design applied to the synthesis of new compounds with specific properties and to the development of new catalysts for chemical transformations in an efficient, clean and selective way. This Master's Degree aims to:
- Provide an advanced, rigorous and highly specialized formation in chemical synthesis, catalysis, reactivity and properties of new molecular substances.
- Provide an advanced training in the main experimental and structural characterization techniques in Molecular Chemistry.
- Introduce the students into scientific research, providing them the suitable competences and knowledge required for their incorporation to research groups or R+D+i departments of chemical companies focused on technological innovation.

Structure:

Students must enrol in the following modules:

Module	ECTS	Semester
60450 - Synthetic Strategies in Advanced Organic Chemistry[ELF]	6	S1
60451 - Molecular Design in Inorganic and Organometallic Chemistry[ELF]	6	S1
60452 - Catalysis[ELF]	6	S1
60453 - Structural Characterization Techniques[ELF]	6	S1
60465 – Master's Dissertation*[ELF]	24	YL

They must also select 12 ECTS from the following list:

Module	ECTS	Semester
60454 - Fundamental Methodologies in Synthesis[ELF]	2	S1
60455 - Bibliographic Resources and Databases[ELF]	2	S1

60456 - Crystallography and Diffraction Techniques[ELF]	2	S2
60457 - Molecular Modelling[ELF]	2	S2
60458 - Advanced Structural Characterization Techniques[ELF]	4	S2
60459 - Asymmetric Catalysis[ELF]	2	S2
60460 - Supramolecular Chemistry[ELF]	2	S2
60461 - Chemistry of Advanced Materials[ELF]	2	S2
60462 - Chemistry at the Frontiers of Biology[ELF]	2	S2
60463 - Sustainable Chemistry and Catalysis[ELF]	2	S2
60464 - Interdisciplinary Seminars[ELF]	2	YL

*Master's Dissertation

The Master's Dissertation (MD) is a 600 hour compulsory project on some of the subjects of the degree. The following list includes some examples of MDs performed in the last years.

- Chiral "bent-core" supramolecular organizations: Preparation and characterization
- Studies on the aza-Prins reaction with chiral alfa-oxigenated aldehydes
- Preparation and conformational studies on peptides having 5-phenylproline
- Preparation of new azobenzene-based photoresponsive polymers
- Synthesis of alfa-methylcysteine derivatives with antioxidant properties for the agro-alimentary industry
- Optimization of the synthesis of glycerol derivatives with application as solvents and preparation and characterization of their eutectic mixtures
- Bimetallic Re-Au complexes for therapy and imaging applications
- Synthesis and properties of metallic complexes with functionalized thioureas
- Different behaviour of platinum and gold in the formation of hydrogen M….H bonds
- Synthesis of metallic oligomers driven by polydentate ligands
- Design and preparation of lanthanide complexes for sensing applications

MSc IN INDUSTRIAL CHEMISTRY

Duration: 1 year full time. 60 ECTS.

Language: Spanish.

Program aims:

The purpose of this Master's Program is to complete graduates' training in Chemistry who aims at acquiring skills required for the professional career in the Chemical Industry and related sectors. This additional training allows graduates to meet the requirements of the industrial sector companies, and it also includes the development of the skills required to access Doctorate Programs in Chemistry. Students enrolled in this Master will acquire extensive knowledge in the field of Industrial Chemistry, necessary for the proper development of the profession in the productive environment. Among others, the following topics will be covered: the main processes and chemicals used in the chemical industry, applications of various advanced methodologies in the industry, the impact of chemicals on the environment and their reduction, the control methods for processes and products at industrial scale, the typical management structure of a chemical company, the existing legislation on the use of chemicals, etc.

Structure:

Students must enrol in the following modules:

Module	ECTS	Semester
60640 - Industrial Chemistry[ELF]	10	YL
60641 - Environmental Legislation and Management Systems[ELF]	9	YL
60642 - Environmental Chemistry[ELF]	8	YL
60643 - Process and Product Control[ELF]	6	S1
60644 - Equipment for Chemical Processes[ELF]	6	S1
60645 - Electrochemistry and Photochemistry for Industry[ELF]	6	S2
60655 – Master's Dissertation*	9	YL

They must also select 2 modules from the following list:

Module	ECTS	Semester
60646 - Alternative Solvents for Industry	3	S2
60647 - Renewable Raw Materials[ELF]	3	S2
60648 - Applied Organic Chemistry	3	S2
60649 - Advanced Inorganic Materials[ELF]	3	S2
60650 - Metrology in the Chemistry Laboratory[ELF]	3	S2

60651 - Risk Assessment in the Chemical Industry	3	S2
60652 - Food Processing Procedures[ELF]	3	S2
60653 - Industrial Catalytic Processes	3	S2
60654 - Pulp and Paper Technology	3	S2

*Master's Dissertation

The Master's Dissertation is a 225 hours compulsory project on any of the subjects of the degree.

RESEARCH GROUPS IN CHEMISTRY

Research in Chemistry at the Faculty of Science has a long tradition and a very high level. University of Zaragoza is consistently ranked among the 100 top universities in the world in Chemistry in Academic Ranking of World Universities (Shanghai's ranking). The research groups in Chemistry in the Faculty are:

- **Bioorganic Chemistry.** PI: Pedro Merino
  http://www.bioorganica.es/
- **Molecular Activation by Organometallics.** PI: Esteban Urriolabeitia
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=38
- **Catalysis, Molecular Separations and Reactor Engineering.** PI: Miguel Menéndez
  http://www.unizar.es/creg/
- **Enantiopure Compounds and Sustainable Processes (CEPS).** PI: M.D. Díaz de Villegas
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=33
- **PLATON.** PI: Carlos Lafuente
  http://platon.unizar.es/
- **Homogeneous Catalysis with Organometallic Compounds.** PI: Jesús Pérez Torrente
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=29
- **Assymetric Organocatalysis.** PI: Raquel Pérez Herrera
  http://hoca.unizar.es/
- **Organometallics and Catalysis.** PI: Miguel Ángel Esteruelas
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=2
- **Inorganic Chemistry and Organometallic Compounds.** PI: José M. Casas
  http://platinum.unizar.es/index.html
- **Nanosensors and Bionalytical Systems** PI: Javier Galbán
  https://grupo-de-biosensores-analiticos.webnode.es
- **Applied Organometallic Chemistry (QOA).** PI: Mariano Laguna
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=42
- **Analytical Spectroscopy and Sensors.** PI: Francisco Laborda
  http://www.unizar.es/geas/
- **Rapid Analysis Methods with Spectroscopic Techniques (MARTE).** PI: Martín Resano
  http://www.unizar.es/marte/
- **Enantioselective Homogeneous Catalysis.** PI: Daniel Carmona
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=4
- **Laboratory for Flavor Analysis and Enology.** PI: Vicente Ferreira
  http://laae.unizar.es/

- **Group of Applied Thermodynamics and Surfaces (GATHERS).** PI: Ana M. Mainar
  http://i3a.unizar.es/datos/grupo/gathers-3
- **Heterogeneous Catalysis in Selective Organic Synthesis.** PI: José Antonio Mayoral
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=7
- **Nanostructured Films and Particles (NFP).** PI: Jesús Santamaría
  http://www.unizar.es/nfp
- **Inorganic Molecular Architecture and Applications.** PI: Cristina Tejel
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=3
- **Catalysis and Mechanisms.** PI: Eduardo Sola
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=32
- **Gold and Silver Chemistry.** PI: M Concepción Gimeno Floría
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=1
- **Liquid Crystals and Polymers (CLIP).** PI: José Luis Serrano
  http://www.unizar.es/liquid_crystals/
- **Thermodynamic of Fluids.** PI: Inmaculada Velasco
- **Amino acids and Peptides.** PI: Carlos Cativiela
  http://www.isqch.unizar-csic.es/ISQCHportal/grupos.do?id=5
- **Chemistry and the Environment.** PI: Jesús Anzano
  http://laser.unizar.es