COURSE DATA

DATA SUBJECT

Code: 46988
Name: Introduction to the Master's Degree in Advanced Materials
Cycle: Master's Degree
ECTS Credits: 8
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2278 - Master in Advanced Materials	Facultat de Química	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2278 - Master in Advanced Materials	Materias Obligatorias	COMPULSORY

COORDINATION

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SUMMARY

Students will take this module from October to December at the university where they are enrolled. The introductory module to the master's degree will familiarize students with the fundamental concepts of advanced materials and prepare them to assimilate the new knowledge and more advanced content of the following modules, which will be taught intensively.

After completing the Introduction to the Master's Degree in Advanced Materials course, the objective is for students to:

1. Understand the main types of 2D materials based on their structural characteristics and composition.

2. Understand the top-down and bottom-up preparation techniques for 2D materials, van der Waals heterostructures, and nanocomposites.

3. Acquire knowledge of the components, molecules, and materials that are essential for the design and construction of quantum devices.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

Previous knowledge of chemistry, physics or materials science as taught in the degrees indicated in the recommended entry profile to the master's degree is required.

COMPETENCES / LEARNING OUTCOMES

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Acquire knowledge of the components, molecules and materials that are fundamental for the design and fabrication of quantum devices.

Analyse the design of nanomaterials for their application in advanced imaging diagnostic techniques and theranostic techniques.

Capacity for learning, responsibility and decision-making: Act autonomously in learning, make informed decisions in different contexts, issue judgements based on experimentation and analysis and transfer knowledge to new situations.

Categorise the use of advanced materials for environmental remediation: water, soil and air treatment. Also consider concepts such as biodegradation.

Creative and entrepreneurial skills: Propose creative and innovative solutions to complex situations or problems within the field of knowledge to respond to diverse professional and social needs.

Critically analyse, evaluate and synthesise new ideas to solve problems in complex or unfamiliar environments within broader contexts in the different areas of impact and application of materials.

Critical thinking, ethical commitment and professional responsibility: Demonstrate critical and self-critical reasoning in the field of the degree, considering aspects such as professional ethics, moral value and the social implications of the different

Describe the functioning of functional nanosystems as materials with antimicrobial and antifungal capabilities.

Design devices with optoelectronic properties.

Design preparation methods for 2D materials, functionalised 2D materials, heterostructures and nanocomposites.

Design smart nanomaterials to solve problems in the field of the biomedical sciences by applying the principles of controlled release of species of interest.

Emotional intelligence: Understand and regulate one's own emotions and those of others to interact and participate effectively and constructively in social and professional life.

Evaluate the lifetime of advanced materials by applying the concept of circular economy to starting products, preparation processes, usage and recycling.

Gender perspective: Know and understand, within the area of the degree, inequalities based on sex and gender in society; integrate different needs and preferences based on sex and gender into the design of solutions and problem-solving.

Have the knowledge and skills necessary to pursue future doctoral studies in the field of materials.

Identify and classify 2D materials and their derivatives.

Interpret the performance of nanosystems in biomedical applications for the controlled release of drugs of interest.

Predict and rationalise properties related to spin-polarised transport in devices.

Predict and rationalise the physical properties of 2D materials.

Relate the type of advanced material to the best methods of production, manufacturing and processing of the final device.

Social commitment and sustainability: Contribute to the design, development and implementation of solutions that respond to social demands, considering the Sustainable Development Goals as a reference.

Students from one area of knowledge (e.g. physics) should be capable of communicating and interacting scientifically with peers from other areas of knowledge (e.g. chemistry) in the analysis and resolution of common problems.

Teamwork and leadership: Collaborate effectively in work teams, taking on responsibilities and leadership roles and contributing to collective improvement and development.

Understand the main techniques for the construction and characterisation of the properties of optoelectronic and spintronic devices.

Understand the main techniques for the preparation, characterisation and properties of 2D materials, van der Waals heterostructures and 2D material nanocomposites, as well as the information they provide and their limitations.

Understand the main technological applications of 2D materials and their derivatives, and be able to place them within the general context of materials science.

Understand the state of the art in 2D materials.

Understand the state of the art in materials for electrocatalysis.

Understand the structure property relationship in different advanced stimuli-responsive materials and distinguish their fields of application.

Understand the technical and conceptual challenges involved in measuring physical properties in electronic devices (such as charge transport, optical properties and magnetic properties).

DESCRIPTION OF CONTENTS

U1.1- Basic concepts on the properties of advanced materials.

- Crystal structures of solids, the reciprocal lattice, defects in solids.
- Electronic structure of materials: Orbitals and bands in one dimension. Bloch functions and band structures; the Fermi level; density of states.
- Relationship between crystal structure and electronic structure and properties: Electrical properties of materials (insulators, semiconductors, metals, and superconductors). Optical properties (light-matter interaction, optical absorption in semiconductors, the concept of exciton and excitonic recombination). Magnetic properties (magnetic interactions; magnetic ordering; magneto-structural correlations). Electrochemical properties (relationship of structure with photocatalytic, electrocatalytic, and energy storage properties).

U1.2- Fundamentals of advanced materials preparation and processing techniques.

- Main preparation techniques for nanostructured materials and nanoparticles.
- Advanced material preparation techniques from solution (intercalation chemistry, colloidal chemistry, supramolecular chemistry) and solid-state (chemical vapor deposition (CVD), chemical vapor transport (CVT), etc.)
- Processing of materials as thin films (Langmuir-Blodgett techniques, layer-by-layer, spin coating, electrochemical growth, self-assembled monolayers (SAMs), molecular sublimation, sputtering, etc.)

U1.3 - Fundamentals of materials characterization techniques

- Diffraction techniques: X-ray diffraction, electron diffraction, neutron diffraction.
- Spectroscopic techniques: vibrational spectroscopy (Raman, IR), photoelectron spectroscopy, and related techniques (XPS, UPS, NEXAFS).
- Microscopy: Electron microscopy, far-field microscopy. Local probe microscopy (AFM, STM, MFM, SNOM)
- Magnetic and electron transport techniques.

- Electrochemical techniques used in energy storage and conversion (voltaamperometry, chronoamperometry, impedance).

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	70,00
Classroom practices	10,00
Total hours	**80,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	60,00
Independent study and work	0,00
Preparation of lessons	0,00
Preparation for assessment activities	60,00
Resolution of case studies	0,00
Total hours	**120,00**

TEACHING METHODOLOGY

The main training activities and teaching methodologies will be **theoretical lectures**, **seminars**, and **formal tutorials**. During the seminars, the theoretical content of the module will be worked on in a practical manner. The methodologies used include article discussions, guided debate and discussion, discussion of practical cases and problem-solving and question-solving, and visits to laboratories and scientific facilities.

Students will be required to complete, individually or in groups, assignments related to some of the concepts explained during the lectures and will also work independently to prepare for the lectures and the module exam.

In formal tutorials, the professor will guide students in their learning process by answering questions about the subject matter, which will serve to reinforce their knowledge. These group tutorials will be conducted primarily in person, as both professors and students are from the same university.

EVALUATION

SE1 - Written exam on core subject content: 30-60%
SE2 - Individual or group work: 30-60%
SE3 - Active participation in in-person activities: 10-20%

SE1 - Written exam on core subject content: Students' achievement of the various learning outcomes will be assessed through individual written exams. The degree of mastery of the main concepts and topics taught in the module will be taken into account, as well as their ability to apply them in different academic and practical contexts. These exams will be administered in person, ensuring equal conditions for all students and facilitating a controlled and reliable assessment. Exams may include different types of questions, such as multiple choice, short and complex answers, and problem-solving, in order to evaluate both the knowledge acquired and the students' analytical, synthesizing, and argumentative skills.

SE2 - Completion of individual or group work: Students' achievement of the various learning outcomes will be assessed through the evaluation of work related to the content taught in the module. These work may be completed individually or in small groups, followed by oral presentation.

Aspects such as depth and precision in understanding the content, coherence and logical structure in the presentation of the work, as well as the correct use of bibliographic sources and the relevance of the conclusions reached will be considered. In addition, the student's ability to work in teams will be taken into account, fostering collaboration skills, effective communication, and joint problem-solving.

The oral presentation of the work will assess the student's ability to communicate information in a clear, structured, and convincing manner, as well as their mastery of the content related to the modules.

SE3 - Active participation in face-to-face activities: continuous assessment of students based on their involvement and commitment in the teaching-learning process. Their participation in debates and discussions and in solving simple problems related to the module's content will be taken into account.

Students' level of interest, understanding, and analytical skills in the content taught will be assessed, as well as their ability to formulate relevant questions and comments and respond to questions and problems posed by the instructor.

Attendance at training activities is mandatory. To pass the module, students must have attended all in-person training activities, except in duly justified cases

REFERENCES