COURSE DATA

Data Subject	
Code	M2-44418
Name	Fundamentals of nanoscience
Cycle	Master's degree
ECTS Credits	4.5

Study (s)

Degree	Center	Acad. year	Period
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Faculty of Chemistry	1	First term

Subject-matter

Degree	Subject-matter	Character
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	2 - Fundamentals of nanoscience	Obligatory

Coordination

Name	Department
RODRÍGUEZ MÉNDEZ, MARÍA LUZ	Physical Chemistry and Inorganic Chemistry- U. de Valladolid
UNTIEDT LECUONA, CARLOS	Applied Physics- U. de Alicante

SUMMARY

The students will acquire the fundamentals and get acquainted with quantum mechanics phenomena that most commonly manifest at the nanoscale. Also the students will get acquainted with the basics of nanochemistry as a tool for building complex systems starting from basic units and their application in various research areas.

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. Previous knowledge of molecular nanoscience and nanotechnology as taught in the Introduction Module is required.

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

2208 - Master's Degree in Molecular Nanoscience and Nanotechnology

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- To possess the necessary knowledge and abilities to continue with future studies in the PhD program in Nanoscience and Nanotechnology.
- For students from field of knowledge (e.g. chemistry) to be able to scientifically communicate and interact with colleagues from another field (e.g. physics) in the resolution of problems laid out by the Molecular Nanoscience and Nanotechnology.
- To know the fundamentals of solid state physics and supramolecular chemistry necessary on molecular nanoscience.
- To know the methodological approaches used in Nanoscience.
- To know the main techniques for molecular systems nanofabrication.
- To acquire the conceptual knowledge about molecular systems self-assembly and self-organisation.
- To assess the relationships and differences between the materials macroscopic properties and those of unimolecular systems and nanomaterials.
- To know the main molecular nanomaterials technological applications and to be able to put them in the Material Science general context.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

The students will acquire the fundamentals and get acquainted with quantum mechanics phenomena that most commonly manifest at the nanoscale. Also the students will get acquainted with the basics of nanochemistry as a tool for building complex systems starting from basic units and their application in various research areas.

DESCRIPTION OF CONTENTS

1. Fundamentals in nanoscience.

0) Introduction:

a) Top-down and bottom-up approaches in Nanoscience.
b) Low dimensionality: Basic concepts and examples of 0-, 1-, 2-dimensional nanostructures.

1) Nanophysics:

a) Nanomechanics.
Review of defects and phonos in solids.
Nanocrystals: the Hall-Petch relationship at the nanoscale.
Nanowires: deformation mechanisms at the nanoscale.
2D materials: graphene, mechanical properties and defects.

b) Nanomagnetism.
Review of basic concepts: Magnetic interactions.
Superparamagnetism.
Macroscopic quantum tunneling.
Magnetoresistance.

c) Nanotransport.
Review of basic transport concepts: conductivity, diffusivity, Einstein relation.
Landauer formalism.
Conductance quantization.
Quantum tunneling.
Resonant quantum tunnelling.
Coulomb blockade.
The Kondo effect.

d) Nanooptics.
Review of basic concepts: Excitons and plasmons.
Optical properties of 0D, 1D, and 2D systems.
Low-dimensional plasmonics.

2) Nanochemistry:

a) Nanochemistry principles
Introduction: Historical evolution and interest.
Review of Nanostructures: Nanoparticles, nanotubes, nanowires, films, 3D structures.
Characterization methods of nanostructures: Microscopies and other tools.

b) Fabrication methods of nanostructures

Nanoparticle synthesis.
Abrasion, colloidal synthesis, sol-gel, etc.
Nanotubes and Nanowires synthesis.
Supramolecular chemistry.
From supramolecular chemistry to self-assembling.
Film preparation.
Traditional techniques.
Nanostructured films: SAMs, Layer-by-Layer, Langmuir-Blodgett, etc.

3) Nanobiology

a) Imaging of biomolecules in vitro. Applications.
b) Biomaterials development.
c) Applications of nanomaterials to biomedical problems.

4) Principles of nanotechnology:

a) Future and present applications.
b) Ethical and social impact.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	22,00	100
Seminars	7,00	100
Tutorials	6,00	100
Other activities	2,00	100
Preparation of evaluation activities	57,50	0
Preparing lectures	18,00	0
TOTAL	**112,50**	

TEACHING METHODOLOGY

The classes of this subject will be taught, together with the rest of the basic module, intensively during 3 weeks in January and each year at a different university.

During the **theory classes**, the teaching staff will give an overview of the subject under study, emphasising new or particularly complex aspects. The necessary bibliographical sources will be indicated for students to study the subject in depth.

The **practical classes** of this subject will be devoted to the organisation of seminars in which problems related to the theoretical content will be posed and solved. Likewise, practical cases and other topics related to the subject will be discussed with the students.

During these hours of practical activities, as far as possible, visits to laboratories and facilities related to the contents of the theoretical classes will be organised. This includes visits to nanomaterials fabrication laboratories.

After the intensive face-to-face classes, the lecturers will ask students a series of **questions** about the contents of the course that the student will have to solve.

Professors will hold tutorials with the students to resolve any doubts and questions they may have. These tutorials will take place in person or remotely (email, videoconference, telephone, etc.) depending on whether the student and teacher are from the same or a different university.

Through all these activities, students will acquire the competences described in the corresponding section. The basic competences will be worked on above all during the seminars.

EVALUATION

The acquisition of the competences of the subject will be assessed by means of a written exam based on the questions posed to the students. The mark for this exam will represent 90% of the final mark for the subject.

Student participation during the training activities will represent 10% of the final grade.

In order to pass the course, it will be necessary to have attended 80% of the face-to-face training activities.

REFERENCES

Basic

- De Nils O. Petersen ·Foundations for Nanoscience and Nanotechnology. CRC Press, 2017
- De B.S. Murty, P. Shankar, Baldev Raj, James Murday Textbook of Nanoscience and Nanotechnology, Springer Berlin Heidelberg 2013
- L Cademartiri, G. A. Ozin, Principles of Nanochemistry John Wiley & Sons, 2009
- G.A. Ozin, A.C. Arsenault: Nanochemistry. The Royal Society of Chemistry, 2005.
- P.J. Collings, Liquid Crystals: Natuers delicate of Mater. 2ª Ed., Princenton University Press, 2002.
- Ulman, An Introduction to Ultrathin Organic Films: from Langmuir-Blodgett to Self-Assembly, Academic Press, San Diego, 1991.

Allen J. Bard, Integrated Chemical Systems: A Chemical Approach to Nanotechnology, Wiley, John & Sons,1994.

Nanoscopic Materials. Emil Roduner. RSC Publishing, 2006.

G.L. Hornyak, J. Dutta, H.F. Tibbals, A.K. Rao, Introduction to Nanoscience. CRC Press (2008)

G.L. Hornyak, H.F. Tibbals, J. Dutta . Fundamentals of Nanotechnology. CRC Press (2008)

Supriyo Datta. Quantum transport: From Atom to Transistor, Cambridge University Press, 2005

David Andrews, Robert H. Lipson, Thomas Nann Elsevier Science. Comprehensive Nanoscience and Nanotechnology, 2019