COURSE DATA

Data Subject	
Code	M1-44417
Name	Introduction to the Master on Molecular Nanoscience and Nanotechnology: Basic concepts
Cycle	Master's degree
ECTS Credits	6.0

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	1 - Introduction to the Master's Degree in molecular nanoscience and nanotechnology: Basic concepts	Obligatory

Coordination

Name	Department
RODRÍGUEZ MÉNDEZ, MARÍA LUZ	Physical Chemistry and Inorganic Chemistry- U. de Valladolid
OTERO MARTÍN, ROBERTO	Condensed Matter Physics- U. Autónoma de Madrid

The objective of this subject is to ensure that all the students share a certain degree of knowledge on Chemistry and Physics needed to understand the basic concepts of Nanoscience, regardless of the previous training that could have previously acquired.

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 (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.

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

The objective of this subject is to ensure that all the students share a certain degree of knowledge on Chemistry and Physics needed to understand the basic concepts of Nanoscience, regardless of the previous training that could have previously acquired. This is necessary since most of the students would have a degree in scientific of technological topics such as Biology, Biochemistry or Chemical Engineering, alongside Physics and Chemistry, and the objectives and contents of their education can be very different from each other.

Students following this course must:

1. Acquire the capacity to use the basic language to describe the structure and chemical bonding or organic and inorganic molecules, including non-bonding intermolecular interactions.

2. Acquire the capacity to use the basic language of Theoretical and Computational Chemistry relative to the previous item.

3. Acquire basic knowledge on the computation of thermodynamical properties from statistical concepts.

4. Acquire the capacity to use the basic language of structure and bonding in Solid State Physics.

5. Acquire the capacity to use the basic language to describe the electronic structure of solid systems

6. Acquire the capacity to use the basic language of Physical Optics in relation with the interactions between the electromagnetic radiation and solid systems.

7. Acquire the capacity to use the basic language to describe electric and magnetic properties of materials.

DESCRIPTION OF CONTENTS

1. Basics concepts in chemistry

1. **Principles of reactivity: Chemical equilibria (4 hours)**
1.1. General concepts in aqueous solutions
1.2. Introduction to acid-base, oxidation-reduction, complex formation and precipitation reactions
2. **Coordination Chemistry (9 hours)**
2.1 Introduction
2.2. Structures of the coordination compounds
2.3 Bond theory
2.4. Kinetics and reaction mechanisms in coordination compounds
3. **Organic Chemistry (9 hours)**
3.1. Constitution of organic compounds: hydrocarbon backbone and functional groups. Basic rules of nomenclature. Basic concept son stereochemistry: Chirality and optical activity. Conformation and configuration. Enantiomers and diastereoisomers.
3.2. Electronic delocalization. Resonance. Aromaticity. Acid-base properties of organic compounds. Structure-acidity relationship.
3.3. 3D structure: Stereochemistry and chirality.
4. Structure determination (4 hours)
4.1. Concepts on symmetry. Symmetry groups.
4.2. Vibrations in molecules. Infrared and Raman spectroscopies. IR spectra of organic and inorganic compounds. Characteristic vibration zones. Factors controlling frequency groups. Main functional groups and characteristic frequencies. Hydrogen bonding. Characteristic frequencies of coordination and organometallic compounds. Ligand coordination. Stereochemistry around a central atom.
4.3. Other spectroscopies and spectrometries. Nuclear Magnetic Resonance (NMR) spectroscopy. General aspects. Basic description of NMR phenomena. Chemical shift. Mass Spectrometry. Fundamentals. Experimental techniques in mass spectrometry.

2. Basics concepts in physics.

1. Crystal structure and reciprocal space (6 hours)
1.1. Interactions among the atoms in a solid
1.2. Crystal structure: unit cell and Bravais lattices.
1.3. Diffraction techniques and reciprocal space
2. Vibrations in molecules and crystals (4 hours)
2.1. Small oscillations around the equilibrium
2.2. Normal vibrational modes in molecules
2.3. Infinite systems. Wave equation. Phonons in crystals.
2.4. Damped and forced oscillations. Resonances.
3. Electronic structure of solids (8 hours)
3.1. Introduction to Quantum Physics. Wave function. Operators and states. Probability amplitudes. Schrödinger equation.
3.2. Quantum confinement and bound states.
3.3. Bands in solids. Effective mass. Density of States.
4. Electromagnetism is materials (8 hours)
4.1. Electric and magnetic forces on charges in motion
4.2. Electrotatics: Gauss Law.
4.3. Magnetostatics: Amperes Law
4.4. Electromagnetic induction: Faradays law.
4.5. Maxwell equation and electromagnetic waves.
4.6. Dielectric constant and electric polarization in materials: Conductors and dielectrics.
4.7. Magnetic susceptibility and magnetic properties of solids
5. Physical properties of solids (4 hours)
5.1. Charge transport: Drudes model and Ohms law.
5.2. Optical properties of solids. Absorption and emission of light. Interband transitions. Plasmons.
5.3. Mechanical properties of solids. Elasticity and Youngs modulus.
5.4. Seminar

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	40,00	100
Seminars	12,00	100
Tutorials	8,00	100
Development of group work	60,00	0
Preparing lectures	30,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

The classes of this subject will be given at the university of registration of the students prior to the classes of the basic module, which will take place in January.

During the theory classes, the lecturers will give an overview of the subject under study, emphasising new or particularly complex aspects. These topics will be worked on in class through the presentation and discussion of scientific articles.

The student will carry out one or more individual assignments related to the concepts explained in the course. This work will consist, preferably, in the presentation by the student of one or several scientific articles from among those proposed by the teacher. Subsequently, the work presented will be discussed in class.

During the seminars, practical cases will be presented and discussed, and problems related to the theoretical content will be posed and solved.

The lecturers will hold tutorials with the students to resolve any doubts and questions they may have. These tutorials will be mainly face-to-face, although they may also be held remotely (email, videoconference, telephone, etc.).

Through all these activities, students will acquire the competences described in the corresponding section. The basic competences will be worked on mainly during the debate and discussion activities

EVALUATION

The acquisition of the competences by the student will be assessed preferably by means of the completion and oral presentation of the assignment by the student.

If the student is unable to do the assignment, he/she will take a written or oral exam on the contents taught in the subject.

This part will represent 70% of the final grade.

Students' attendance and participation in discussions and in the resolution of questions and problems will also be assessed. This part will represent 30% 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

- R.H. Petrucci. QUIMICA GENERAL : PRINCIPIOS Y APLICACIONES MODERNAS 11. Ed. Pearson. 2017
Guía docente M1 - 54070 pág. 10
Martin Silberberg, Patricia Amateis . Chemistry: The Molecular Nature of Matter and Change 8th Edition. 2017. MacGrawHill. 2017. ISBN1259631753
L Cademartiri, G. A. Ozin, Principles of Nanochemistry John Wiley & Sons, 2009 .
P.J. Collings, Liquid Crystals: Naturers delicate of Mater. 2ª Ed., Princenton University Press, 2002.
E.H Wichmann, B.P.C. Física cuántica (Curso de Física de Berkeley) · 2020
C. Kittel, P. McEuen ·Introduction to Solid State Physics. Wiley. 2018
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

Additional

- (UT 1.1) Petrucci. Quimica general e inorgánica.Tomo 1
(UT 1.2) Glen E. Rodgers. Química Inorgánica. Introducción a la Química de la Coordinación, del estado sólido y descriptiva. Capítulos 1 a 5
(UT 1.3.) J. E. McMurry, Organic Chemistry, 8th Edition; Brooks/Cole, 2012
P. Y. Bruice, Química Orgánica, 8ª Edición; Pearson-Prentice Hall, México, 2008
(UT 1.4.) Spectrometric Identification of Organic Compounds, R.M. Silverstein, F.X. Webster, D. Kiemle, 7th Ed., John Wiley and Sons, 2004.Infrared and Raman Spectra of Inorganic and Coordination Compounds, K. Nakamoto, 6th Ed., John Wiley and Sons, 2009. Libro de tablas: Determinación Estructural de Compuestos Orgánicos. E. Pretsch, P. Bühlmann, C. Affolter, A. Herrera, R. Martínez, Editorial Masson, Barcelona, 2004.