Teaching Guide				
Identifying Data				2022/23
Subject (*)	Spectroscopy		Code	610G04017
Study programme	Grao en Nanociencia e Nanotecnoloxía			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	2nd four-month period	Second	Obligatory	6
Language	SpanishGalicianEnglish			
Teaching method	Face-to-face			
Prerequisites				
Department	Química			
Coordinador	Canle López, Moisés	E-mail	moises.canle@udc.es	
Lecturers	Canle López, Moisés Fernandez Perez, Maria Isabel	E-mail	moises.canle@udc.es isabel.fernandez.perez@udc.es	
Web	http://moodle.udc.es/			
General description	This subject tackles the foundations of the main technical spectroscopic and difractometric techniques for characterisation of nanomaterials and nanostrutures. It seeks the acquisition of the necessary basic knowledge, skills and competences associated to the understanding and application of the mentioned techniques.			

Study programme competences	
Code	Study programme competences
A1	CE1 - Comprender los conceptos, principios, teorías y hechos fundamentales relacionados con la Nanociencia y Nanotecnología.
A2	CE2 - Aplicar los conceptos, principios, teorías y hechos fundamentales relacionados con la Nanociencia y Nanotecnología a la resolución de problemas de naturaleza cuantitativa o cualitativa.
A3	CE3 - Reconocer y analizar problemas físicos, químicos, matemáticos, biológicos en el ámbito de la Nanociencia y Nanotecnología, así como plantear respuestas o trabajos adecuados para su resolución, incluyendo el uso de fuentes bibliográficas.
A5	CE5 - Conocer los rasgos estructurales de los nanomateriales, incluyendo las principales técnicas para su identificación y caracterización
A7	CE7 - Interpretar los datos obtenidos mediante medidas experimentales y simulaciones, incluyendo el uso de herramientas informáticas, identificar su significado y relacionarlos con las teorías químicas, físicas o biológicas apropiadas.
B2	CB2 - Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio
B3	CB3 - Que los estudiantes tengan la capacidad de reunir e interpretar datos relevantes (normalmente dentro de su área de estudio) para emitir juicios que incluyan una reflexión sobre temas relevantes de índole social, científica o ética
B6	CG1 - Aprender a aprender
B7	CG2 - Resolver problemas de forma efectiva.
C2	CT2 - Dominar la expresión y la comprensión de forma oral y escrita de un idioma extranjero
C3	CT3 - Utilizar las herramientas básicas de las tecnologías de la información y las comunicaciones (TIC) necesarias para el ejercicio de su profesión y para el aprendizaje a lo largo de su vida
C8	CT8 - Valorar la importancia que tiene la investigación, la innovación y el desarrollo tecnológico en el avance socioeconómico y cultural de la sociedad

Learning outcomes			
Learning outcomes	Study programme competences		
· To understand structural characteristics in nanoscience, as well as the main technical of structural characterisation.	A1 A2 A3	B2 B3	
· To understand, recognise and analyse new problems, and be able to plan strategies to solve them.	A5 A7	B7	C8

· To be able to interpret the data from observations and measurements in the laboratory.	A7	B2 B3 B6 B7	C3
· To be able to apply spectroscopic techniques as tools in identification of nanostructures and nanoparticles.	A2 A3 A5 A7	B2 B3	C2 C8

Contents	
Topic	**Sub-topic**
1. Introduction to spectroscopy.	Electromagnetic radiation and matter. Resonant and non resonant processes. Transition dipole moment. Spontaneous emission. Selection rules. Types of spectra. Population of energy levels. Lmbert-Beer Law. Factors that determine the shape and width of spectral bands. Principles of laser action.
2. Vibrational spectroscopy.	Symmetry in Chemistry. Applications to Spectroscopy. IR spectroscopy Electron energy loss spectroscopy: EELS Raman spectroscopy
3. Electronic spectroscopy	UV-Vis spectroscopy Diffuse reflectance spectroscopy Luminescence: fluorescence, phosphorescence Surface plasmon resonance Size quantum effects
4. Photoelectron spectroscopy	UPS spectroscopy XPS spectroscopy Auger spectroscopy Other
5. Introduction to diffraction techniques	XR diffraction: XRD, SAXS XR fluorescence Electron diffraction: LEED Neutron diffraction
6. Electron microscopy	Scanning electron microscopy (SEM, SEM-EDS) Transmission electron microscopy (TEM) Atomic force microscopy (AFM)
7. Magnetic resonance techniques	Nuclear magnetic resonance: NMR, SS-NMR, MAS-NMR Electron and paramagnetic resonance: EPR
8. Other spectroscopies	Mössbauer spectroscopy Ionic spectrometry: RBS, SIMS Dielectric response spectroscopy

Planning				
Methodologies / tests	**Competencies**	**Ordinary class hours**	**Student?s personal work hours**	**Total hours**
Seminar	A2 A3 A7 B2 B3 B7 C3	8	16	24

Mixed objective/subjective test	A1 A2 A5 A7 B2 B3 B7	4	0	4
Oral presentation	A2 A7 B2 B3 C2 C3	2	0	2
Multiple-choice questions	A2 A3 A5 B2 B3 B6 B7 C2 C3	8	16	24
Guest lecture / keynote speech	A1 A2 A5 A7 B2 B3 C8	31	62	93
Personalized attention		3	0	3
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	**Description**
Seminar	This activity is planned to be carried out in groups as reduced as possible, with the aim to deepen in a dynamic and argumentative way in the distinct topics. The success of this methodology depends on the active participation of the students.
Mixed objective/subjective test	Combination of different types of questions, tests and problems, brief answer or short essay, evaluating knowledge, capacity of reasoning and critical ability.
Oral presentation	Oral presentation of a case taken from the case studies activity, or a similar one proposed by the lecturer. The activity includes debate on the subject that is presented.
Multiple-choice questions	Ao longo do cuadrimestre, a medida que se avanza na materia, vanse engadindo tests no campus virtual. O alumnado debe respostar a estos tests, que computan para a avaliación, nun tempo limitado e breve. O obxectivo e fomentar o estudo paulatino e progresivo da materia.
Guest lecture / keynote speech	Lectures with audiovisual or blackboard support in which the fundamental aspects of the subject are put forward, with possibility of participation of the students.

Personalized attention	
Methodologies	**Description**
Oral presentation	It aims to guide to the students in the understanding of the problem posed and of the possible strategies to solve it. It will be jointly scheduled between lecturers and students, as needed. It will be carried out at lecturers' office. Will be distributed in 12 sessions of 15 min along the semester. The students with recognition of part time dedication and exemption of assistance will have to assist to at least a personal tutory for each seminar (=8 tutories) and one out of two case studies (=4 tutories), previously scheduled in agreement with the lecturers.

Assessment			
Methodologies	**Competencies**	**Description**	**Qualification**
Mixed objective/subjective test	A1 A2 A5 A7 B2 B3 B7	Final examination with two parts, one of a theoretical type (50%), including test questions, of short answer and/or essay, and another of problems solution (50 %), in which the ability to apply theoretical contents for problems solution will be assessed.	60
Oral presentation	A2 A7 B2 B3 C2 C3	Quality of the presented information. Abilities shown in the presentation. Capacity to defend the own presentation.	20
Multiple-choice questions	A2 A3 A5 B2 B3 B6 B7 C2 C3	Tests de resposta múltiple realizados a través do campus virtual. Valórase a adquisición de coñecementos sobre a materia e a capacidade de respostar cuestións sobre a mesma nun tempo limitado, poñendo de manifesto claridade nos conceptos. Estos test non se consideran recuperables na segunda oportunidade.	20

Assessment comments
The aim is to evaluate the acquisition of knowledge, critical capacity, synthesis, comparison, elaboration, application and originality of the students. In order to make the best use of the subject, students must attend all face-to-face activities. First opportunity. In order for the case study and oral presentation activities to be taken into account, a minimum grade of 4.0/10 must be obtained in each of the two parts of the mixed test. The final grade is obtained by applying the established percentages and the previously established restrictions. Second opportunity. The mixed test is repeated, since the activities related to the multiple-choice test (which reflects the continuity and progressiveness in the acquisition of knowledge) and the oral presentation (since it is not possible to debate it with the presence of all the students) are considered unrepeatable. Thus, in this second opportunity, the mixed test becomes worth 80% of the final grade (half for each of its parts), which is obtained by applying the established percentages and the previously established restrictions. In any of both opportunities, if a minimum grade of 4.0/10 is obtained in each of the parts of the mixed test, the subject will be considered as failed even if the final grade, calculated according to the corresponding percentages, is equal or higher than 5/10. In this case, the final grade will be 4.5/10. Honors: if there are several students with the same grade who are eligible for the MH, and the number of MH available is less than the number of students, they will be called to a written test. Students evaluated in the second opportunity will only be eligible for the MH if the number of MHs was not covered in its totality in the first opportunity. Grade of "not presented": applies to students who had participated in evaluable activities that represent less (

Sources of information	
Basic	- Guozhong Cao (2004). Nanostructures & nanomaterials. London : Imperial College Press - Kurt W. Kolasinski (2012). Surface Science. Foundations of Catalysis and Nanoscience. Chichester : Wiley - Rolando M.A. Roque-Malherbe (2010). The Physical Chemistry of Materials. Boca Raton : CRC Press - Julio A. Gonzalo, José de Frutos, Jorge García (2002). Solid State Spectroscopies. Basic Principles and Applications. Singapore: World Scientific
Complementary	- S. Roy Morrison (1990). The Chemical Physics of Surfaces. London: Plenum Press - Arthur W. Adamson, Alice P. Gast (1997). Physical Chemistry of Surfaces. Chichester : Wiley - D.K. Chakrabarty, B. Viswanathan (2009). Heterogeneous Catalysis. Kent : New Age Science - Atkins, Peter W. (2014). Atkins' Physical Chemistry. Oxford : Oxford University Press - Levine, Ira N. (2004). Fisicoquímica. Madrid : McGrawhill - D. C. Harris (1989). Symmetry and spectroscopy an introduction to vibrational and electronic spectroscopy. New York : Dover - A. M. Ellis (2005). Electronic and photoelectron spectroscopy fundamentals and case studies.. Cambridge : Cambridge University Press - J. Keeler (2010). Understanding NMR spectroscopy. Chichester : John Wiley and Sons - Ooi, Li-ling (2010). Principles of x-ray crystallography. Oxford : Oxford University Press Materiais proporcionados ao longo do curso polos docentes.Materiais proporcionados ao longo do curso polos docentes.

Recommendations
Subjects that it is recommended to have taken before
Advanced Crystallography/610G04042 Fundamentals of Quantum Theory/610G04015 Physics: Electricity and Magnetism/610G04007 Chemistry: Structure and Bonding/610G04005 Physics: Mechanics and Waves/610G04002
Subjects that are recommended to be taken simultaneously
Synthesis and Preparation of Nanomaterials/610G04020 Instrumental Analysis/610G04014
Subjects that continue the syllabus

Techniques of Characterisation of Nanomaterials 2/610G04030 Techniques of Characterisation of Nanomaterials 1/610G04025 Surface Science/610G04021 Solid State/610G04022
Other comments
- It is recommended to review assiduously the theoretical concepts introduced in the maximum lessons, as well as to solve simultaneously the questions in exercises that will be proposed.- It is not advisable to study only by class notes. It is recommended to elaborate your own material by completing the notes.- It is strongly recommended to make use of the tutorial hours to clarify doubts and deepen our knowledge.- Green Campus Program of the Faculty of Science. To help achieve an immediate sustainable environment and comply with point 6 of the "Environmental Declaration of the Faculty of Science (2020)", the work of this subject will be requested in virtual format and computer support.