Teaching Guide				
Identifying Data				2019/20
Subject (*)	Green Chemistry		Code	610500021
Study programme	Mestrado Universitario en Ciencias. Tecnoloxías e Xestión Ambiental (plan 2012)			
Descriptors				
Cycle	Period	Year	Type	Credits
Official Master's Degree	2nd four-month period	First	Optional	3
Language	Spanish			
Teaching method	Face-to-face			
Prerequisites				
Department	Química			
Coordinador	Martinez Cebeira, Montserrat	E-mail	monserrat.martinez.cebeira@udc.es	
Lecturers	Martinez Cebeira, Montserrat	E-mail	monserrat.martinez.cebeira@udc.es	
Web				
General description	The sustainable chemistry is based on the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. In this course the principles, fundamentals and some examples of applications of green chemistry will be presented The general objectives of this course are: - Define sustainable chemistry and give an overview of the historical developments that led to the development of green chemistry and other related discoveries. - Establish the principles of sustainable chemistry and define in practice chemical processes associated with sustainable chemistry. - Define the tools and the general areas of sustainable chemistry. - Recognize the toxicity / hazard as a physical / structural property that can be designed and manipulated. - Provide examples of application of green chemistry. - Become familiar with current trends in sustainable chemistry.			

Study programme competences	
Code	Study programme competences
A1	Coñecemento das realidades interdisciplinares da Química e do Medio Ambiente, dos temas punteiros nestas disciplinas e das perspectivas de futuro.
A3	Capacitar ao alumno para o desenvolvemento dun traballo de investigación nun campo da Química ou do Medio Ambiente, incluíndo os procesos de caracterización de materiais, o estudo das súas propiedades fisicoquímicas e biolóxicas e dos procesos que poden sufrir no medio natural.
A5	Capacitación para o deseño de vías de síntese e retrosíntese de novos compostos.
A6	Coñecemento do comportamento de diferentes especies químicas e dos procesos aos que poden estar sometidas unha vez liberadas no medio ambiente, incluíndo as súas relacións entre distintos compartimentos ambientais.
A10	Relacionar a presenza de especies químicas no medio natural cos conceptos de toxicidade e biodisponibilidade.
A11	Coñecer as distintas técnicas experimentais e computacionales orientadas á caracterización de mecanismos de reacción.
A16	Comprender a problemática asociada aos resíduos, os modos de xestionalos e as principais tecnoloxías de tratamento de resíduos.
A17	Coñecer a problemática asociada coa enerxía e as súas fontes, as tecnoloxías máis empregadas actualmente e as de futuro.
A19	Coñecemento e interpretación da lexislación, normativa e procedementos administrativos básicos sobre medios acuosos, chans e atmosferas. Comprensión das bases científicas e económicas da sustentabilidade.
B1	Posuír e comprender coñecementos que acheguen unha base ou oportunidade de ser orixinais no desenvolvemento e/ou aplicación de ideas, a miúdo nun contexto de investigación.
B2	Que os estudantes saiban aplicar os coñecementos adquiridos e a súa capacidade de resolución de problemas en contornas novas ou pouco coñecidos dentro de contextos máis amplos (ou multidisciplinares) relacionados coa súa área de estudo.

B3	Que os estudantes sexan capaces de integrar coñecementos e enfrontarse á complexidade de formular xuízos a partir dunha información que, sendo incompleta ou limitada, inclúa reflexións sobre as responsabilidades sociais e éticas vinculadas á aplicación dos seus coñecementos e suizos.
B6	Ser capaz de analizar datos e situacións, xestionar a información dispoñible e sintetizala, todo iso a un nivel especializado.
B8	Comprender, a un nivel especializado, as consecuencias do comportamento humano na contorna ambiental.
C1	Ser capaz de traballar en equipos, especialmente nos interdisciplinares e internacionais.
C2	Ser capaz de manter un pensamento crítico dentro dun compromiso ético e no marco da cultura da calidade.
C3	Ser capaz de adaptarse a situacións novas, mostrando creatividade, iniciativa, espírito emprendedor e capacidade de liderado.
C5	Dominar a expresión e a comprensión de forma oral e escrita dun idioma estranxeiro.
C9	Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.
C11	Valorar a importancia que ten a investigación, a innovación e o desenvolvemento tecnolóxico no avance socioeconómico e cultural da sociedade.

Learning outcomes			
Learning outcomes	Study programme competences		
Know the principles and concepts of sustainable chemistry	AC1 AC5 AC6 AC17	BC1 BC2	CC2 CC3 CC5 CC9
Knowing the fundamentals for waste minimization and deepen the idea of environmental efficiency	AC1 AC3 AC10 AC16	BC3 BC6 BC8	CC2 CC5 CC9
Knowing the importance of catalysis in sustainable processes	AC3 AC5 AC11 AC19	BC1 BC2 BC3	CC2 CC3
Importance of using alternative solvents with low toxicity, renewable raw materials and non-classical reaction conditions in industrial processes	AC1 AC3 AC5 AC11 AC17 AC19	BC3 BC6	CC1 CC2 CC3 CC9 CC11
Design development not harmful processes according to the principles of sustainable chemistry	AC1 AC3 AC5 AC17	BC1 BC2 BC3 BC6 BC8	CC1 CC2 CC3 CC5 CC9 CC11

Contents	
Topic	Sub-topic

Topic 1. Principles and Concepts of Sustainable Chemistry	Introduction. Definition of sustainable chemistry. Sustainable development and green chemistry. The Twelve Principles of green chemistry Atom economy. Definition. Examples. Toxicity. Measuring toxicity. Associated risks. Measuring and controlling environmental performance. Waste minimization techniques.
Topic 2. Catalysis and Green Chemistry	Introduction to catalysis. Catalyst types Heterogeneous catalysts. Introduction. Zeolites. Industrial applications Homogeneous catalysis. Transition-metal catalysis. Asymmetric catalysis. Introduction. Basic concepts. Examples. Phase-transfer catalysis. Biocatalysis. Photocatalysis.
Topic 3. Alternate solvents with low toxicity	Introduction. Solvent free systems. Supercritical fluids. Water as reaction solvent. Ionic liquids. Fluorous biphase solvents.
Topic 4. Renewable Resources	Basic concepts. Energy from renewable resources. Chemicals from renewable feedstocks
Topic 5. Non-conventional reaction conditions and alternative energy sources	Photochemical reactions. Chemistry using microwaves. Sonochemistry. Electrochemical synthesis. Designing Greener Processes.
Topic 6. Industrial case studies	Industrial case studies of sustainable chemistry

Planning				
Methodologies / tests	Competencies	Ordinary class hours	Student?s personal work hours	Total hours
Supervised projects	A5 A11 A17 B1 B6 B8 C2 C3 C1	3	12	15
Laboratory practice	A3 A5 A11 B1 B6 C11	7	14	21
Mixed objective/subjective test	A1 A5 A6 A10 A11 A16 A17 B2 B6 C2	1	2	3
Objective test	A1 A5 A6 A10 A11 A16 A17 B2 B6 C2	2	4	6
Guest lecture / keynote speech	A1 A3 A5 A11 A17 A19 B2 B3 C5 C9	8	20	28
Personalized attention		2	0	2
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	Description

Supervised projects	Students will develop a work a recent scientific paper or examples of sustainable chemical processes, directly related to the subject of course, that could expose it in public. In this work, previously agreed with the teacher, the student it shall indicate the highlights, and the understanding of it through a short summary. It will evaluate the ability to summarize, arrange and present the concepts of the subject presented. There will also be questions after exposure in order to assess both the knowledge acquired by the student as well as their critical ability.
Laboratory practice	The student will be able to develop a set of experiments based on the material resources and the availability of laboratories according to the coordination schedule or computational examples of the aspects developed in the guest lecture. It may also analyse and manage information available at a specialized level of sustainable processes either in the literature or in a research laboratory (e.g. CICA) and prepare a scientific report.
Mixed objective/subjective test	It will be A written test consisting of a series of questions developed by the students to evaluate the level of skills acquired during the course the student.
Objective test	Periodically, in the lectures, the student will conduct several short tests for continuous assessment.
Guest lecture / keynote speech	The course consists of a series of classroom sessions where the general principles of each topic will be presented. The literature and material to more adequately follow classes will be previously available in Moodle. Some of these classes are also devoted to the resolution of proposed questions in advance to students so that it can work on them before the relevant meeting. Also, periodically, you can make some short tests to the continued evaluation of the student.

Personalized attention	
Methodologies	**Description**
Supervised projects Laboratory practice	Personalized care sessions are programmed to guide students in making the ward work and resolve potential issues associated. Students a appretiation part-time and academic exemption will be attended in tutorial hours (by appointment).

Assessment			
Methodologies	**Competencies**	**Description**	**Qualification**
Objective test	A1 A5 A6 A10 A11 A16 A17 B2 B6 C2	There will be some short tests of multiple choice or short-answer, according to the specified in section metodology.	40
Supervised projects	A5 A11 A17 B1 B6 B8 C2 C3 C1	Process evaluation of student learning will to take place continuously, both classroom activities as non-face tutored. Besides, it will be considered in the evaluation of students the compulsory course attendance, assessed through active participation in the sessions and targeted academic papers that could be presented through an oral exposure. The continuous assessment of student during the semester will be up a point in the overall assessment.	30
Laboratory practice	A3 A5 A11 B1 B6 C11	Attendance to practical classes is necessary and active participation will contribute to the final grade.	10
Mixed objective/subjective test	A1 A5 A6 A10 A11 A16 A17 B2 B6 C2	The student also may be assessed through a written exam.	20

Assessment comments

To pass the subject it will be necessary to get at least 5 points 8maximun 10 points) between the different assessment activities.
Since the qualification is based on the model of continuous assessment, specifically it assesses student progression throughout the four-month period with a maximum of 1 point that may be added to the final grade.
Students who do not attend and do not participate in scheduled activities will score zero points in this section on two occasions, unless the student has recognized a part-time academic and attendance waiver of exemption or specific modalities of learning or supporting diversity. Students will be evaluated by the mixed test (20%), supervised projects (30%) and the objective test performed during programmed personalized attention (50 %).
In the case of exceptional, objectified and appropriately justified circumstances, the Professor may fully or partly exempt the student to perform the process of continuous assessment. The student that is in this circumstance must pass a specific test that leaves no doubt about achieving academic skill in both oportunities.
The student will have a rating of not submitted when making less than 25% of academic activities scheduled.

Sources of information	
Basic	- Lancaster, M. (2002). Green Chemistry: An Introductory Text.. Royal Society of Chemistry: Cambridge, UK - Anastas, P. T.; Warner, J. C. (1998). Green Chemistry: Theory and Practice.. Oxford University Press: Oxford, UK - Cabildo Miranda, M. P.; Cornago Ramírez, M. P.; Escolástico León, C.; Esteban Santos, S.; Farrán Mor (2006). Procesos Orgánicos de Bajo Impacto Ambiental. Química Verde.. UNED: Madrid
Complementary	- Anastas, P. T., Farris, C. A., Eds. (1994). Benign by Design. Alternative Synthetic Design for Polution Prevention. ACS Symposium Series 577. American Chemical Society: Washington - Tundo, P., Anastas, P., Eds. (2000). Green Chemistry. Challenging Perspectives.. Oxford University Press: Oxford, UK - Anastas, P. T., Williamson, T. C., Eds. (1996). Green Chemistry. Designing Chemistry for the Environment. ACS Symposium Series 626. American Chemical Society: Washington - Anastas, P. T., Williamson, T. C., Eds. (1998). Green Chemistry. Frontiers in Benign Chemical Syntheses and Processes. Oxford University Press: Oxford, UK

Recommendations
Subjects that it is recommended to have taken before
Subjects that are recommended to be taken simultaneously
Subjects that continue the syllabus
Other comments

(*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.