



## Teaching Guide

| Teaching Guide           |                                                                                                                                                                                                                                                                                                                                                                                                 |        |                       |           |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------|-----------|
| Identifying Data         |                                                                                                                                                                                                                                                                                                                                                                                                 |        |                       | 2022/23   |
| Subject (*)              | Structural Analysis and Synthetic Planning                                                                                                                                                                                                                                                                                                                                                      |        | Code                  | 610500003 |
| Study programme          | Mestrado Universitario en Ciencias, Tecnoloxías e Xestión Ambiental (plan 2012)                                                                                                                                                                                                                                                                                                                 |        |                       |           |
| Descriptors              |                                                                                                                                                                                                                                                                                                                                                                                                 |        |                       |           |
| Cycle                    | Period                                                                                                                                                                                                                                                                                                                                                                                          | Year   | Type                  | Credits   |
| Official Master's Degree | 1st four-month period                                                                                                                                                                                                                                                                                                                                                                           | First  | Optional              | 6         |
| Language                 | Spanish                                                                                                                                                                                                                                                                                                                                                                                         |        |                       |           |
| Teaching method          | Face-to-face                                                                                                                                                                                                                                                                                                                                                                                    |        |                       |           |
| Prerequisites            |                                                                                                                                                                                                                                                                                                                                                                                                 |        |                       |           |
| Department               | Química                                                                                                                                                                                                                                                                                                                                                                                         |        |                       |           |
| Coordinador              | Maestro Saavedra, Miguel Anxo                                                                                                                                                                                                                                                                                                                                                                   | E-mail | miguel.maestro@udc.es |           |
| Lecturers                | Maestro Saavedra, Miguel Anxo                                                                                                                                                                                                                                                                                                                                                                   | E-mail | miguel.maestro@udc.es |           |
| Web                      | campusvirtual.udc.es                                                                                                                                                                                                                                                                                                                                                                            |        |                       |           |
| General description      | The subject is aimed at expanding the knowledge of Chemistry graduates in both Structural Determination and organic synthesis. In a first block applications of the mass spectrometry in Organic Chemistry and the two-dimensional NMR techniques are introduced. In a second block the strategies in organic synthesis and asymmetric synthesis, as well as the new methodologies are studied. |        |                       |           |

## 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.                                                                                                                                           |
| A2   | Deseño de novas especies químicas e materiais con propiedades determinadas.                                                                                                                                                                                                                  |
| 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.       |
| A4   | Coñecer en profundidade as características e fundamentos de diversos modelos químicos para o estudo de sistemas orgánicos, inorgánicos e biolóxicos, incluídos os materiais con proxección tecnolóxica.                                                                                      |
| A5   | Capacitación para o deseño de vías de síntese e retrosíntese de novos compostos.                                                                                                                                                                                                             |
| A22  | Dominar as técnicas instrumentais de análises máis típicas no ámbito químico profesional.                                                                                                                                                                                                    |
| 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 coñecidas 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 xuízos. |
| B4   | Que os estudantes saiban comunicar as súas conclusións e os coñecementos e razóns últimas que as sustentan a públicos especializados e non especializados dun modo claro e sen ambigüedades.                                                                                                 |
| B5   | Que os estudantes posúan as habilidades de aprendizaxe que lles permitan continuar estudando dun modo que haberá de ser en gran medida autodirixido ou autónomo.                                                                                                                             |
| B6   | Ser capaz de analizar datos e situacións, xestionar a información dispoñible e sintetizala, todo iso a un nivel especializado.                                                                                                                                                               |
| B7   | Ser capaz de planificar adecuadamente desenvolvementos experimentais, a un nivel especializado.                                                                                                                                                                                              |
| C1   | Ser capaz de traballar en equipos, especialmente nos interdisciplinares e internacionais.                                                                                                                                                                                                    |
| C3   | Ser capaz de adaptarse a situacións novas, mostrando creatividade, iniciativa, espírito emprendedor e capacidade de liderado.                                                                                                                                                                |
| C4   | Expresarse correctamente, tanto de forma oral coma escrita, nas linguas oficiais da comunidade autónoma.                                                                                                                                                                                     |
| C5   | Dominar a expresión e a comprensión de forma oral e escrita dun idioma estranxeiro.                                                                                                                                                                                                          |
| C6   | Utilizar as ferramentas básicas das tecnoloxías da información e as comunicacións (TIC) necesarias para o exercicio da súa profesión e para a aprendizaxe ao longo da súa vida.                                                                                                              |

|     |                                                                                                                                               |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 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 |          |
| Knowledge of two-dimensional NMR techniques and strategies for the planning of an organic synthesis |  | AC1                         | BC1 CC1  |
|                                                                                                     |  | AC2                         | BC2 CC3  |
|                                                                                                     |  | AC3                         | BC3 CC4  |
|                                                                                                     |  | AC4                         | BC4 CC5  |
|                                                                                                     |  | AC5                         | BC5 CC6  |
|                                                                                                     |  | AC22                        | BC6 CC9  |
|                                                                                                     |  |                             | BC7 CC11 |

| Contents                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                          | Sub-topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Unit 1: Mass spectrometry.                                     | Ionization methods: IC, FAB, APCI, ESI and MALDI. Applications for obtaining the molecular formula of a compound. Mass spectrometry of biomolecules: proteins and nucleic acids. Tandem mass spectrometry (MS / MS).                                                                                                                                                                                                                                                                  |
| Unit 2: Multidimensional NMR technics.                         | The chemical shift and spin-spin coupling. Relaxation in NMR: NOE, nOediff. The polarization transfer: INEPT, DEPT and APT experiments. Two-dimensional NMR spectroscopy, basic concepts. Experiments COSY, HETCOR, NOESY, ROESY and INADEQUATE. Reverse Spectroscopy: HMQC Vs. HSQC. HMBC. Methods of J-resolved: JHH; JCH. Measurements of long-distance coupling constants, LR-COSY and J-HMBC. More complex experiments: 1H-1H TOCSY (HOHAHA), HSQC-TOCSY, HSQC-NOESY and HETLOC. |
| Unit 3. Structural analysis in Organic Chemistry               | Strategies for solving combined problems.                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Unit 4. Asymmetric synthesis                                   | Introduction. Basic principles. Kinetic resolution. Stereoselective synthesis: chiral auxiliaries. Catalytic processes.                                                                                                                                                                                                                                                                                                                                                               |
| Unit 5. Planning and strategies in organic synthesis           | Retrosynthetic analysis. Selectivity in organic synthesis. Protecting groups in organic synthesis.                                                                                                                                                                                                                                                                                                                                                                                    |
| Unit 6. Reduction reactions.                                   | Reduction of alkenes: Asymmetric hydrogenation. Hydroboration reactions. Reactions of hydroformylation. Reduction of ketones and imines. Hydrogenation reactions. Reactions with oxazaborolidines. Hydrosilylation reactions.                                                                                                                                                                                                                                                         |
| Unit 7. Oxydation reactions.                                   | Epoxydation of alkenes. Epoxydation of allylic alcohols. Epoxydation with salts of manganese (salen). Formation of azidirines. Dihydroxylation of alkenes. Aminohydroxylation of alkenes. Oxidation of Baeyer-Villiger and related                                                                                                                                                                                                                                                    |
| Unit 8. Reaction of nucleohylic addition to carbonyl compounds | Addition of organometallic zinc. Addition of cyanide ion. Alkylation of aldehydes. The aldol reaction. Addition reactions to imines. Baylis-Hillman reaction. Conjugate Addition Reactions.                                                                                                                                                                                                                                                                                           |

| Planning                       |                                                        |                      |                               |             |
|--------------------------------|--------------------------------------------------------|----------------------|-------------------------------|-------------|
| Methodologies / tests          | Competencies                                           | Ordinary class hours | Student?s personal work hours | Total hours |
| Guest lecture / keynote speech | A1 A2 A3 A4 A5 B1<br>B2 B3 B4 B5 B6 B7<br>C3 C1 C9 C11 | 20                   | 40                            | 60          |
| Laboratory practice            | A5 A22 B1 B2 B5 B6<br>B7 C3 C1 C4 C6                   | 10                   | 14.9                          | 24.9        |



|                         |                                                  |     |      |      |
|-------------------------|--------------------------------------------------|-----|------|------|
| Supervised projects     | A5 B1 B2 B3 B4 B5<br>B6 C3 C1 C4 C5 C6<br>C9     | 2   | 8    | 10   |
| Objective test          | A1 A2 A3 A5 A22 B1<br>B2 B3 B4 B6 C3 C1<br>C4 C5 | 2   | 8    | 10   |
| Oral presentation       | B4 B5 C4 C5 C6 C9<br>C11                         | 1   | 4    | 5    |
| Collaborative learning  | B1 B2 B3 B4 B5 B6<br>B7 C3 C1                    | 9.5 | 26.6 | 36.1 |
| Introductory activities | A1 A2 A3 C9 C11                                  | 0.5 | 0.5  | 1    |
| 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                                                                                                                                                                                                                                                                                                                 |
| Guest lecture / keynote speech | Development of the fundamental contents of the program through theoretical explanations and practical examples.                                                                                                                                                                                                             |
| Laboratory practice            | Analysis and resolution of the problems selected by the teacher. Structural elucidation of unknown compounds by analysis and integration of NMR and mass data.<br>Laboratory sessions are proposed that will focus on the use of new methodologies in Organic Synthesis: Microwave, solid phase synthesis, ultrasound, etc. |
| Supervised projects            | Elaboration of a report on the prediction and / or interpretation of the reactivity of organic compounds with special attention to the use of computational methods                                                                                                                                                         |
| Objective test                 | A written exam is scheduled, in order to evaluate the degree of assimilation and the ability to apply the contents of the subject by students.                                                                                                                                                                              |
| Oral presentation              | Exhibition of the tutored work, with support of new technologies.                                                                                                                                                                                                                                                           |
| Collaborative learning         | Preparation of the expositive classes, resolution of exercises in groups and / or individualized.                                                                                                                                                                                                                           |
| Introductory activities        | Presentation of the course and its programming of contents, activities and evaluation criteria                                                                                                                                                                                                                              |

| Personalized attention                        |                                                                                                                                                                         |
|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                                 | Description                                                                                                                                                             |
| Laboratory practice<br>Collaborative learning | Follow-up and orientation during the drafting of the report on synthetic strategies and structural analysis, in individual sessions in the teacher's tutoring schedule. |

| Assessment          |                                                  |                                                                                                                                                                                                                                                                                |               |
|---------------------|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Methodologies       | Competencies                                     | Description                                                                                                                                                                                                                                                                    | Qualification |
| Laboratory practice | A5 A22 B1 B2 B5 B6<br>B7 C3 C1 C4 C6             | Continuous evaluation of the work in the laboratory, which will take into account the interest and attitude of the student, the skill achieved in the use of synthetic tools, as well as the resolution of problems of structural elucidation by analyzing spectroscopic data. | 50            |
| Supervised projects | A5 B1 B2 B3 B4 B5<br>B6 C3 C1 C4 C5 C6<br>C9     | The preparation of a bibliographical revision work and its writing in a concise and rigorous manner, using the appropriate terminology, on some of the contents presented in the master sessions.                                                                              | 10            |
| Oral presentation   | B4 B5 C4 C5 C6 C9<br>C11                         | Evaluation of the oral expositions corresponding to the work of bibliographical revision and the solutions of the problems of structural elucidation                                                                                                                           | 10            |
| Objective test      | A1 A2 A3 A5 A22 B1<br>B2 B3 B4 B6 C3 C1<br>C4 C5 | Solving Problems of Organic Synthesis and Structural Determination.                                                                                                                                                                                                            | 30            |



## Assessment comments

It is necessary to obtain 50% to pass the subject. For a methodology to be accounted for, it must exceed at least 40% of the grade.

## Sources of information

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>         | <ul style="list-style-type: none"><li>- Crews, P, Rodríguez, J., Jaspers, M. (2009). Organic Structure Analysis. 2nd Ed. Osxord University Press; New York</li><li>- E. N. Jacobsen, A. Pfaltz, H. Yamamoto (1999). Comprehensive Asymmetric Catalysis . Berlin, Springer</li><li>- Smith, M. B (2002). Organic Synthesis. Boston, McGraw-Hill</li><li>- Gewert J. A.; Görlitzer, J.; Götze, S.; Looft, J.; Menningen, P.; Nöbel, T.; Schirock, H.; Wulff, C. (2000). Organic Synthesis Workbook. Weinheim, Wiley</li><li>- Bittner, C.; Busemann, A. S.; Griesbach, U.; Haunert, F.; Krahner, W.-R.; Modi, A.; Olschimke, J. (2000). Organic Synthesis Workbook II. Weinheim, Wiley</li><li>- Tom Kinzel... [et al.] (2007). Organic synthesis workbook III. Weinheim, Wiley</li><li>- Wyatt, P.; Warren, S. (2007). Organic Synthesis: Strategy and Control.. England, Wiley</li></ul> |
| <b>Complementary</b> | <ul style="list-style-type: none"><li>- Hesse, M. (1995). Métodos Espectroscópicos en Química Orgánica. . Madrid, Síntesis</li><li>- Eliel, E. L. (1994). Stereochemistry of Organic Compounds. New York, Wiley</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

## 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.