

## COURSE DESCRIPTION

### COURSE DETAILS

Title (of the course): **AMPLIACIÓN DE QUÍMICA INORGÁNICA**

Code: 100457

Degree/Master: **GRADO DE QUÍMICA**

Year: 3

Name of the module to which it belongs: FUNDAMENTAL

Field: QUÍMICA INORGÁNICA

Character: OBLIGATORIA

Duration: FIRST TERM

ECTS Credits: 6.0

Classroom hours: 60

Face-to-face classroom percentage: 40.0%

Study hours: 90

Online platform: <https://moodle.uco.es/>

### LECTURER INFORMATION

Name: TIRADO COELLO, JOSE LUIS (Coordinador)

Department: QUÍMICA INORGÁNICA E INGENIERÍA QUÍMICA

Area: QUÍMICA INORGÁNICA

Office location: Marie Curie Building, 1s floor

E-Mail: [iq1ticoj@uco.es](mailto:iq1ticoj@uco.es)

Phone: 957218637

URL web: <https://moodle.uco.es/>

Name: ORTIZ JIMENEZ, GREGORIO FCO.

Department: QUÍMICA INORGÁNICA E INGENIERÍA QUÍMICA

Area: QUÍMICA INORGÁNICA

Office location: Marie Curie Building, 1s floor

E-Mail: [q72maorg@uco.es](mailto:q72maorg@uco.es)

Phone: : 957218663

URL web: <https://moodle.uco.es/>

### PREREQUISITES AND RECOMMENDATIONS

#### Prerequisites established in the study plan

None specified.

#### Recommendations

The English language level must be at least B1.

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### INTENDED LEARNING OUTCOMES

CB4	Knowledge of a foreign language
CB6	Problem solving
CB10	Ability to study independently for continued professional development.
CE3	Principles and procedures used in chemical analysis and in the characterisation of chemical compounds.
CE4	The main structural investigation techniques, including spectroscopy.
CE10	Structural aspects of chemical elements and their compounds, including stereochemistry
CE20	Study, properties and applications of the materials
CE21	The ability to show knowledge and understanding of the essential facts, concepts, principles, and theories relating to chemistry
CE22	The ability to apply knowledge to solve qualitative and quantitative problems according to previously developed models
CE23	Competency to evaluate, interpret and summarise Chemical data and information.
CE24	Ability to recognise and carry out good scientific practices.
CE28	Ability to carry out standard laboratory procedures involved in analytical and concise work in relation with organic and inorganic systems.
CE31	Interpretation of data from previous observations and measurements in the laboratory in terms of their significance and the theories that support them

### OBJECTIVES

- To understand and to know how to apply the experimental techniques commonly used in the structural determination of inorganic compounds.
- To acquire knowledge on the bonding, structure, reactivity and properties of inorganic solids.

### CONTENT

#### 1. Theory contents

##### Section 1. Experimental methods for determining the structure of inorganic compounds

**Lesson 1.** Theory of symmetry point groups. Operations, representations and character tables. Transformation of reducible representations into irreducible. The direct product. Application of the group theory to study vibrational spectroscopy. Symmetry of the normal modes. Fundamental levels and transitions. Selection rules in IR and Raman spectroscopies.

**Lesson 2.** Nuclear magnetic resonance (NMR) spectroscopy. Nuclear spin levels in the presence of a magnetic field. Resonance condition and instrumentation. Dynamic aspects. Applications to structural studies of inorganic molecules. Solid-state NMR. Magic angle spinning. Applications to the study of inorganic solids.

**Lesson 3.** Photoelectron spectroscopy. Instrumentation and radiation used. Auger spectroscopy. Calibration. Chemical information obtained. Intensity of photoelectrons. Study of the core levels. Chemical shift. Satellites and spin-orbit coupling. Studies of valence energy levels. Fine structure of the spectra.

**Lesson 4.** Crystal Systems. Bravais lattices. The 32 crystallographic point groups. Space group symmetry. Symmorphic and nonsymmorphic groups. International Tables of Crystallography. X-ray diffraction. Single crystal methods. The powder method. Structural determinations by powder X-ray and neutron diffraction. Rietveld refinement.

**Lesson 5.** Microscopy techniques. The transmission electron microscope. Sample Preparation. Fundamentals of image formation and interpretation. High-resolution electron microscopy. Electron diffraction. Scanning tunneling



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microscopy: instrumental and applications. Atomic force microscopy. AFM modes.

### Section 2. Inorganic Solids

**Lesson 6.** Description and prediction of crystal structures based on packing of spheres. Close packed structures. Related structures: substitutions, interstitial positions, distortions and complex ions. Coordination polyhedra and connectivity. Relations with the crystallographic description.

**Lesson 7.** Bonding-structure relations. Ionic solids. Pauling postulates. Bond directionality. Mooser-Pearson diagrams. The equation of Phillips and Van Vechten. Covalent solids and dimensionality. Glasses: Zachariasen rules. Metals. Band theory and structures. Molecular solids: Kitaigorodskii theory. Hydrogen bonds and crystal structure. Water in crystals: Baur theory.

**Lesson 8.** Defects in solids. point defects. Thermodynamics of Shottky and Frenkel defects. Unidimensional defects: Edge and screw dislocations. The Burgers vector. Dislocation density. Two-dimensional defects: phase boundaries. High-angle and low-angle grain boundaries. Stacking faults. Three-dimensional defects: inclusions and pores. Nonstoichiometric solid. Vacancies and interstices. Defect assimilation: vacancies and clusters. Defects elimination: Crystallographic shear structures. Misfit structures.

**Lesson 9.** Reactivity and synthesis of solids. Phase diagrams and phase rule. Reconstructive or displacive polymorphic transformations. Solid-solid reactions. Interdiffusion. Kirkendall effect. Solid-gas reactions. Oxidation. Thermal decomposition.

**Lesson 10.** Properties of inorganic solids. Mechanical properties. Hardness and microstructure. Magnetic properties: Ferro-, ferri- and antiferro-magnetism. Curie-Weiss and Neel laws. Electrical properties. Superconductors. Optical properties. Solid-state laser.

## 2. Practical contents

There will be a collection of exercises and problems in units related to the theoretical content, discussion and resolution being the basis of Guided Activities included in section Seminars. Three hours in total, 2 h of problems and 1 h tutorials will be ascribed to each unit.

The summary of the contents of these units is the following:

- Symmetry elements of and point groups
- Character Tables and IR and Raman spectroscopy
- NMR and XPS
- Space Groups
- X-ray diffraction
- Visit and use of large scientific instruments
- Bonding-structure relationships
- Defects in solids
- Reactivity and properties of solids

## METHODOLOGY

### General clarifications on the methodology (optional)

The goal of the lectures is the presentation to the students of the different theoretical contents specified in the course syllabus, which is included in this Teaching Guide. The presentations contain a series of knowledge adequately structured to constitute the basis for further study of each of the topics of the syllabus. This lecture tool is not intended to establish fixed limits for each subject or a unique development of its contents. Rather, it should enhance and facilitate the subsequent work of the student, indicating the main lines to follow in understanding the subject matter and showing the most important connections between the different lessons on the agenda. Additionally, an important contribution of the lectures should be pointing to the most useful literature for each of the program sections. The use of ancillary techniques in the exhibition, videos and dimensional models of molecules and crystal lattices, will be very useful to facilitate understanding.

Classes dedicated to practical contents involve the development of seminar activities and tutorials. The seminar will overcome the limitations inherent to the lectures, being able to develop a new and more interactive approach



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to the subject under study. In addition, specific details not included in the lectures in order to not obscure the fundamental principles that must be transmitted, can be examined in more detail in the seminars. The application of the basic principles to a wide range of real problems will also be developed. Moreover, tutoring students is a great opportunity to answer those questions that have not been solved based on the literature assigned to the subject, through direct contact with the teacher.

### Methodological adaptations for part-time students and students with disabilities and special educational needs

Methodological adaptations for part-time students and students with disabilities and special educational needs shall be conducted in accordance with the regulations of the center and the casuistry of students.

The criteria for students of second and subsequent enrollment in relation to practical activities and assessment methodology are the same as for students of first registration.

### Face-to-face activities

Activity	Large group	Medium group	Total
<i>Assessment activities</i>	5	-	5
<i>Lectures</i>	28	-	28
<i>Seminar</i>	-	18	18
<i>Tutorials</i>	-	9	9
<b>Total hours:</b>	<b>33</b>	<b>27</b>	<b>60</b>

### Off-site activities

Activity	Total
<i>Activities</i>	15
<i>Exercises</i>	15
<i>Information search</i>	10
<i>Reference search</i>	10
<i>Self-study</i>	40
<b>Total hours</b>	<b>90</b>

## WORK MATERIALS FOR STUDENTS

Coursebook  
Dossier  
Exercises and activities

### Clarifications

The e-learning platform will contain the teaching guide, as well as detailed information on theory topics, presentations, links to Interest, exercises and problems and their solutions, and results of evaluation tests. It will also be a valuable communication tool between students and professors.

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## EVALUATION

Intended learnig	Debate	Document Analysis	Exams	Problem solving	Real and/or simulated tasks	Text commentary
CB10		X				X
CB4		X				
CB6	X		X	X	X	
CE10	X	X	X	X	X	X
CE20	X	X	X	X	X	X
CE21	X		X	X	X	X
CE22				X	X	
CE23	X	X	X	X		X
CE24			X	X	X	
CE28			X	X	X	
CE3			X	X	X	
CE31			X	X	X	
CE4	X	X	X	X	X	X
<b>Total (100%)</b>	<b>10%</b>	<b>10%</b>	<b>40%</b>	<b>20%</b>	<b>10%</b>	<b>10%</b>
<b>Minimum grade</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>

(\*)Minimum grade necessary to pass the course

#### Method of assessment of attendance:

Attendance to debates and problem solving = from 0 (no attendance) to 1 (all).

#### General clarifications on instruments for evaluation:

The whole group will be evaluated by grading the student with Text commentary (10%), Document Analysis (10%) and final exam 40% of the final grade), and problem solving (20%). The practice lessons group will also be assessed continually by Real and/or simulated tasks (10%) and debate (10%) in seminar sessions.

To achieve this latter aspect, the following rubric will be used:

Participation

Advanced: The student offers himself voluntarily to solve the exercise on the board.

Proficient: The student participates when prompted by the teacher.

Unsatisfactory: The student offers resistance to participate in the seminar.

Behavior

Advanced: The student shows interest and actively involves in the seminar.

Proficient: The student remains silent; he shows interest but does not participate.

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### Development Exercise

Advanced: The student clearly set out the exercise.

Proficient: The student is limited to writing the result mechanically.

Unsatisfactory: Student doubts and babbles during the course of the exercise.

### Validity of results

Advanced: The student reaches the correct result.

Proficient: The student needs a little help, but correctly solves the exercise.

Unsatisfactory: The student does not complete the exercise and / or reaches incorrect results.

### Discussion

Advanced: The student responds decisively to the questions put to him.

Proficient: The student doubts, but finally responds appropriately.

Unsatisfactory: The student does not know how to answer the questions.

### Clarifications on the methodology for part-time students and students with disabilities and special educational needs:

Assessment adaptations for part-time students and students with disabilities and special educational needs shall be conducted in accordance with the regulations of the center and the casuistry of students.

The criteria for students of second and subsequent enrollment in relation to practical activities and assessment methodology are the same as for students of first registration.

### Qualifying criteria for obtaining honors:

*According to UCO rules*

## BIBLIOGRAPHY

### 1. Basic Bibliography

Adams, D.M. Sólidos inorgánicos: introducción a los conceptos de la química estructural en estado sólido, Alhambra, (1986).

Callister, W.D. Introducción a la ciencia e ingeniería de los materiales, Reverté (2007).

Cotton, F.A. La teoría de grupos aplicada a la química. Limusa Mexico (1991).

Housecroft, C.E. Química Inorgánica. Pearson-Prentice Hall (2006).

Shriver, D.F., Atkins, P.W. y C.H. Langford Química Inorgánica. Reverté (2004).

### 2. Further reading

Akitt, J.W. NMR and Chemistry. Chapman. N.Y. (1992).

Bermudez Polonio, J. Métodos de difracción de rayos X. Ciencia y Técnica (1981).

Burns, G. y Glazer A.M. Space groups for solid state scientists. Academic (1978).

Cox, P.A., The Electronic Structure and Chemistry of Solids. Oxford Univ. Press. Oxford. (1987).

Drago, R.S. Physical methods for Chemists. Saunders N.Y. (1992).

Hull, D. Introduction to Dislocations. Pergamon. N.Y. (1975).

Hyde, B.G. y Andersson, S. Inorganic Crystal Structures. Wiley. N.Y. (1989).

O'Keefe, M. y Navrotsky, A. (eds.). Structure and Bonding in Crystals. Academic. N.Y. (1981).

Rao, C.N.R. y Gopalakrishnan, J. New directions in solid state chemistry. Cambridge Univ. Press. Londres (1986).

Schmalzried, H. Solid State Reactions. Verlag. N.Y. (1971).

Tilley, R.J.D. Defect Crystal Chemistry. Blackie. N.Y. (1987).

Tilley, R. Understanding Solids. Wiley, N.Y. (2004).

Wells, A.F. Structural Inorganic Chemistry. Clarendon. Oxford. (1975).

West, A.R. Solid State Chemistry and Its Applications. 4 ed. Wiley. N.Y. (1984).

## COURSE DESCRIPTION

## COORDINATION CRITERIA

Tasks performance

## SCHEDULE

Period	Assessment activities	Lectures	Seminar	Tutorials
1# Week	0,0	2,0	0,0	0,0
2# Week	0,0	2,0	0,0	0,0
3# Week	0,0	2,0	2,0	1,0
4# Week	0,0	2,0	2,0	1,0
5# Week	0,0	2,0	0,0	0,0
6# Week	0,0	2,0	2,0	1,0
7# Week	0,0	2,0	0,0	0,0
8# Week	2,0	2,0	0,0	0,0
9# Week	0,0	2,0	2,0	1,0
10# Week	0,0	2,0	2,0	1,0
11# Week	0,0	2,0	2,0	1,0
12# Week	2,0	2,0	2,0	1,0
13# Week	0,0	2,0	0,0	0,0
14# Week	0,0	2,0	2,0	1,0
15# Week	1,0	0,0	2,0	1,0
<b>Total hours:</b>	<b>5,0</b>	<b>28,0</b>	<b>18,0</b>	<b>9,0</b>

The methodological strategies and the evaluation system contemplated in this Course Description will be adapted according to the needs presented by students with disabilities and special educational needs in the cases that are required.

## CONTINGENCY PLAN: CASE SCENARIO A

Case scenario A will correspond to a diminished on-site academic activity due to social distancing measures affecting the permitted capacity of classrooms.



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### METHODOLOGY

#### General clarifications on the methodology on case scenario A

A multimodal (hybrid) teaching system will be adopted, combining both on-site and remote classes via videoconference (synchronous) that will be held in the timetable approved by the corresponding Faculty or School. The time distribution of teaching activities (both on-site and remote) will be decided by the aforementioned Faculties and Schools bearing in mind the permitted capacity of classrooms and social distancing measures as established at that time.

The goal of the lectures is the presentation to the students of the different theoretical contents specified in the course syllabus, which is included in this Teaching Guide. The presentations contain a series of knowledge adequately structured to constitute the basis for further study of each of the topics of the syllabus. This lecture tool is not intended to establish fixed limits for each subject or a unique development of its contents. Rather, it should enhance and facilitate the subsequent work of the student, indicating the main lines to follow in understanding the subject matter and showing the most important connections between the different lessons on the agenda. Additionally, an important contribution of the lectures should be pointing to the most useful literature for each of the program sections. The use of ancillary techniques in the exhibition, videos and dimensional models of molecules and crystal lattices, will be very useful to facilitate understanding.

Classes dedicated to practical contents involve the development of seminar activities and tutorials. The seminar will overcome the limitations inherent to the lectures, being able to develop a new and more interactive approach to the subject under study. In addition, specific details not included in the lectures in order to not obscure the fundamental principles that must be transmitted, can be examined in more detail in the seminars. The application of the basic principles to a wide range of real problems will also be developed. Moreover, tutoring students is a great opportunity to answer those questions that have not been solved based on the literature assigned to the subject, through direct contact with the teacher.

### EVALUATION

Intended learnig	Debate	Document Analysis	Exams	Problem solving	Real and/or simulated tasks	Text commentary
CB10		X				X
CB4		X				
CB6	X		X	X	X	
CE10	X	X	X	X	X	X
CE20	X	X	X	X	X	X
CE21	X		X	X	X	X
CE22				X	X	
CE23	X	X	X	X		X
CE24			X	X	X	
CE28			X	X	X	
CE3			X	X	X	



## COURSE DESCRIPTION

Intended learnig	Debate	Document Analysis	Exams	Problem solving	Real and/or simulated tasks	Text commentary
CE31			X	X	X	
CE4	X	X	X	X	X	X
<b>Total (100%)</b>	<b>10%</b>	<b>10%</b>	<b>40%</b>	<b>20%</b>	<b>10%</b>	<b>10%</b>
<b>Minimum grade</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>

(\*)Minimum grade necessary to pass the course

### Method of assessment of attendance (Scenario A):

Attendance to debates and problem solving = from 0 (no attendance) to 1 (all).

### General clarifications on instruments for evaluation (Scenario A):

The whole group will be evaluated by grading the student with Text commentary (10%), Document Analysis (10%) final exam (40% of the final grade), and problem-solving (20%). There will be four continuous evaluation tests (CET) consisting of a series of short questions and a problem corresponding to a group of program lessons. Students who do not pass some of these tests should do them again in the exam of the teaching unit. The practice lessons group will also be assessed continually by Real and/or simulated tasks (10%) and debate (10%) in seminar sessions.

To achieve this latter aspect, the following rubric will be used:

#### Participation

Advanced: The student offers himself voluntarily to solve the exercise on the board.

Proficient: The student participates when prompted by the teacher.

Unsatisfactory: The student offers resistance to participate in the seminar.

#### Behavior

Advanced: The student shows interest and actively involves in the seminar.

Proficient: The student remains silent; he shows interest but does not participate.

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#### Development Exercise

Advanced: The student clearly set out the exercise.

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#### Validity of results

Advanced: The student reaches the correct result.

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#### Discussion

Advanced: The student responds decisively to the questions put to him.

Proficient: The student doubts, but finally responds appropriately.

Unsatisfactory: The student does not know how to answer the questions.

Extraordinary call for the 2020-2021 academic year for students of second enrollment or higher: the same assessment and weighting instruments apply.

## COURSE DESCRIPTION

### **Clarifications on the methodology for part-time students and students with disabilities and special educational needs (Scenario A):**

Assessment adaptations for part-time students and students with disabilities and special educational needs shall be conducted in accordance with the regulations of the center and the casuistry of students.

The criteria for students of second and subsequent enrollment in relation to practical activities and assessment methodology are the same as for students of first registration.

### **Qualifying criteria for obtaining honors (Scenario A):**

*According to UCO rules*

## CONTINGENCY PLAN: CASE SCENARIO B

Case scenario B will bring about a suspension of all on-site academic activities as a consequence of health measures.

## METHODOLOGY

### **General clarifications on the methodology on case scenario B**

On-site teaching activities will be held via videoconference (synchronous) in the timetable approved by the corresponding Faculty or School. Alternative activities will be proposed for reduced groups in order to guarantee the acquisition of course competences.

The goal of the lectures is the presentation to the students of the different theoretical contents specified in the course syllabus, which is included in this Teaching Guide. The presentations contain a series of knowledge adequately structured to constitute the basis for further study of each of the topics of the syllabus. This lecture tool is not intended to establish fixed limits for each subject or a unique development of its contents. Rather, it should enhance and facilitate the subsequent work of the student, indicating the main lines to follow in understanding the subject matter and showing the most important connections between the different lessons on the agenda. Additionally, an important contribution of the lectures should be pointing to the most useful literature for each of the program sections. The use of ancillary techniques in the exhibition, videos and dimensional models of molecules and crystal lattices, will be very useful to facilitate understanding.

Classes dedicated to practical contents involve the development of seminar activities and tutorials. The seminar will overcome the limitations inherent to the lectures, being able to develop a new and more interactive approach to the subject under study. In addition, specific details not included in the lectures in order to not obscure the fundamental principles that must be transmitted, can be examined in more detail in the seminars. The application of the basic principles to a wide range of real problems will also be developed. Moreover, tutoring students is a great opportunity to answer those questions that have not been solved based on the literature assigned to the subject, through direct contact with the teacher.

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## EVALUATION

Intended learnig	Debate	Document Analysis	Exams	Problem solving	Real and/or simulated tasks	Text commentary
CB10		X				X
CB4		X				
CB6	X		X	X	X	
CE10	X	X	X	X	X	X
CE20	X	X	X	X	X	X
CE21	X		X	X	X	X
CE22				X	X	
CE23	X	X	X	X		X
CE24			X	X	X	
CE28			X	X	X	
CE3			X	X	X	
CE31			X	X	X	
CE4	X	X	X	X	X	X
<b>Total (100%)</b>	<b>10%</b>	<b>10%</b>	<b>40%</b>	<b>20%</b>	<b>10%</b>	<b>10%</b>
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Moodle Tools	Análisis de documentos	Comentarios de texto	Debate	Exámenes	Pruebas de ejecución de tareas reales y/o simuladas	Resolución de problemas
Asistencia			X		X	
Cuestionario	X	X		X		X
Foro			X		X	
Participación			X			X
Pruebas simultáneas por videoconferencia				X		
Rúbrica de evaluación			X		X	
Tarea	X	X				X
Videoconferencia			X		X	

## COURSE DESCRIPTION

### Method of assessment of attendance (Scenario B):

Attendance to debates and problem solving = from 0 (no attendance) to 1 (all).

### General clarifications on instruments for evaluation (Scenario B):

The whole group will be evaluated by grading the student with Text commentary (10%), Document Analysis (10%) and final exam 40% of the final grade), and problem solving (20%). The practice lessons group will also be assessed continually by Real and/or simulated tasks (10%) and debate (10%) in seminar sessions.

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Extraordinary call for the 2020-2021 academic year for students of second enrollment or higher: the same assessment and weighting instruments apply.

### Clarifications on the methodology for part-time students and students with disabilities and special educational needs (Scenario B):

Assessment adaptations for part-time students and students with disabilities and special educational needs shall be conducted in accordance with the regulations of the center and the casuistry of students.

The criteria for students of second and subsequent enrollment in relation to practical activities and assessment methodology are the same as for students of first registration.

### Qualifying criteria for obtaining honors (Scenario B):

According to UCO rules